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FEASIBILITY STUDY OF THE DISSOLUTION RATES OF URANIUM ORE DUST, URANIUM CONCENTRATES AND URANIUM COMPOUNDS IN SIMULATED LUNG FLUID

by

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Research report

FEASIBILITY STUDY OF THE DISSOLUTION RATES OF URANIUM ORE DUST, URANIUM CONCENTRATES AND URANIUM COMPOUNDS IN SIMULATED LUNG FLUID

Experimental work carried out and report prepared by R. Robertson, Becquerel Laboratories Inc. under contract to the Atomic Energy Control Board.

ABSTRACT

A flow-through apparatus has been devised to study the dissolution in simulated lung fluid of aerosol materials associated with the Canadian uranium industry.

The apparatus has been experimentally applied over 16 day extraction periods to approximately 2g samples of < 38um and 53-75um particle-size fractions of both Elliot Lake and Mid-Western uranium ores. The extraction of uranium-238 was in the range 24-60% for these samples. The corresponding range for radium-226 was 8-26%. Thorium-230, lead-210, polonium-210 and thorium-232 were not significantly extracted. It was incidentally found that the elemental composition of the ores studied varies significantly with particle size, the radionuclide-containing minerals and several extractable stable elements being concentrated in the smaller size fraction.

Samples of the refined compounds uranium dioxide and uranium trioxide were submitted to similar 16 day extraction experiments. Approximately 0.5% of the uranium was extracted from a 0.258g sample of unsintered (fluid bed) uranium dioxide of particle size < 38um. The corresponding figure for a 0.292g sample of uranium trioxide was 97%.

Two aerosol samples on filters were also studied. Of the 88ug uranium initially measured on stage 2 of a cascade impactor sample collected from the yellow cake packing area of an Elliot Lake mill, essentially 100% was extracted over a 16 day period. The corresponding figure for an open face filter sample collected in a fuel fabrication plant and initially measured at 288ug uranium was approximately 3%.

Recommendations are made with regard to further work of a research nature which would be useful in this area. Recommendations are also made on sampling methods, analytical methods and extraction conditions for various aerosols of interest which are to be studied in a work of broader scope designed to yield meaningful data in connection with lung dosimetry calculations.

DISCLAIMER

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RÉSUMÉ

Un appareil de tamisage a été créé pour étudier la dissolution dans le fluide pulmonaire simulé de matières en suspension dans l'air en rapport avec l'industrie de l'uranium au Canada.

L'appareil a été utilisé dans le cadre d'une expérience portant sur des périodes d'extraction d'une durée de 16 jours pour des échantillons d'environ 2 g de fractions de particules de < 38 µm et de 53 à 75 µm tant pour le minerai d'uranium d'Elliot Lake que celui de la région centrale de l'Ouest. Dans ces échantillons, l'extraction de l'uranium 238 variait de 24 à 60 pour 100. La variation correspondante pour le radium 226 était de 8 à 26 pour 100. L'extraction du thorium 230, du plomb 210, du polonium 210 et du thorium 232 n'a pas été importante. Incidemment, il a été découvert que la composition élémentaire des minerais étudiés variait considérablement suivant le format des particules, puisque les minéraux à teneur en radionucléides et plusieurs éléments stables extractables étaient concentrés dans les plus petites fractions.

Des échantillons des composés raffinés de bioxyde d'uranium et de trioxyde d'uranium ont été soumis à des expériences d'extraction semblables d'une durée de 16 jours. Environ 0,5 pour 100 de l'uranium a été extrait d'un échantillon de 0,258 g de bioxyde d'uranium non concrété (fond de fluide) de particules de < 38 µm de grosseur. Les données correspondantes pour un échantillon de 0,292 g de trioxyde d'uranium étaient de 97 pour 100.

Deux échantillons sur filtres de particules en suspension dans l'air ont aussi été étudiés. Parmi les 88 µg d'uranium initialement mesurés à la deuxième étape d'un échantillon du précipitateur en cascade prélevé de l'aire d'emballage du concentré uranifère d'une usine d'Elliot Lake, 100 pour 100 ont été extraits durant une période de 16 jours. Les données correspondantes pour un échantillon de filtre à découvert prélevé dans une usine de fabrication de combustibles et initialement mesuré à 288 µg d'uranium étaient d'environ 3 pour 100.

Des recommandations sont formulées concernant des travaux de recherche additionnels qui seraient utiles dans ce domaine. D'autres recommandations portent sur les méthodes d'échantillonnage, les méthodes d'analyse et les conditions d'extraction pour diverses particules en suspension dans l'air qui présentent de l'intérêt et qui doivent faire l'objet d'une étude de plus grande envergure afin de recueillir des données valables sur les calculs en matière de dosimétrie pulmonaire.

PREFACE

The Atomic Energy Control Board is contemplating a broad study of the in-vitro lung fluid solubility behaviour of aerosols of occupational health concern in the Canadian uranium industry.

The intent of the work presented here was to provide data and gain experience which would allow good planning decisions to be made regarding AECB's future work in the field.

A good deal of published work [1-12] had already been done in the area, but important questions remained unanswered regarding AECB's particular requirements. These questions were largely connected with sample size and sampling methodology, the solubility and other properties of the local materials to be studied, the extraction system to be used, the relative importance of the various radionuclides with regard to lung dose, and the radioanalytical methods to be applied and their sensitivity, precision, etc.

At a meeting in Ottawa between the contractor and AECB prior to the contract for this work being let, two key decisions were made which would allow the work to proceed. It was decided to begin the project using simulated aerosols generated from bulk material by grinding and sieving. In this way, samples of adequate size and of known characteristics were certain to be relatively quickly obtained, although it was recognized that the processing of such samples would not yield data which would be directly applicable in lung dosimetry calculations. The second decision was to aim to develop a flow-through extraction system which would as closely as possible simulate lung conditions and which would overcome the shortcomings of previous systems, particularly batch processes.

From this point the project developed in a stepwise fashion with a good deal of discussion and feedback taking place between AECB and the contractor as the work proceeded. Four formal meetings took place: two with an AECB steering committee and two with an AECB-appointed external review panel. It was generally recognized that the work was of a research and development nature and that firm deadlines and outcomes were difficult to determine. Several experimental problems were encountered during the project leading to slight changes in direction and several additions were made to the work in progress.

ACKNOWLEDGEMENT

The author acknowledges the significant contributions of the Review Panel and the Steering Committee towards this work.

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FEASIBILITY STUDY OF THE DISSOLUTION RATES OF URANIUM ORE DUST, URANIUM CONCENTRATES AND URANIUM COMPOUNDS IN SIMULATED LUNG FLUID

A. INTRODUCTION

In lung dosimetry calculations it is important to have good information on the rate of dissolution in lung fluid of the radionuclides of interest from the aerosol matrix of interest. The work presented here is an effort towards developing methodology to obtain that information with regard to a broad spectrum of aerosols giving rise to occupational health concerns in the Canadian uranium industry. It is expected that the recommendations of this report will serve as part of the basis for future AECB efforts in this area.

B. SAMPLES PROCESSED

1. Bulk Uranium Ores

Two types of Canadian uranium ore were treated. The first of these was collected by AECB personnel from the Elliot Lake region of northern Ontario. Samples of 10-20g of this material were taken from the rafters and other horizontal surfaces from several locations within a processing mill. Several such samples were combined and further pulverised in a steel shatter box. The pulverised material was then dry-sieved to yield fractions of < 38um (14.5g), 38-53um (50.2g), 53-75um (10.8g) and > 75um (3.1g). The < 38um and the 53-75um fractions were subjected to analysis and extraction processes.

The second type of ore was from the so-called Mid-Western deposits of Saskatchewan. A sample of approximately 600g of this material was pulverised and dry-sieved to yield fractions of < 38um (48g), 38-53um (332g) and 53-75um (203g). The < 38um and the 53-75um fractions were subjected to analysis and extraction processes.

2. Bulk Refined Uranium Compounds

Bulk samples of refinery grade uranium dioxide and uranium trioxide were supplied by AECB. The uranium dioxide was unsintered material produced by the fluid bed process. The samples, which were in powder form, were sieved to yield about 1g of < 38um material. Samples of the < 38um materials were subjected to analysis and extraction processes.

3. Aerosols on Filters

During the early part of this work, over one hundred filter samples were analysed by neutron activation for uranium and thorium. These were a mixture of open-face filters and cascade impactor stages. The open-face filter samples were collected from a refinery and from a fuel fabrication plant and were supplied through AECB. The cascade impactor samples were from the mining and milling operations at Elliot Lake and were supplied by the Canadian Institute for Radiation Safety (CAIRS).

A stage 2 cascade impactor sample from the yellow-cake packing area of a mill was selected for extraction processing. The amount of uranium on this glass fibre filter was 88ug. The volume of air sampled was 5.4m^3 and the nominal diameter of particles on this stage 2 was 7.8um.

The second aerosol filter selected was a glass-fibre, open-face filter sample collected from an area involved in unsintered uranium dioxide processing within a fuel fabrication plant. The amount of uranium on this filter was 288ug.

C. EXTRACTION EQUIPMENT AND PROCEDURES

1. Equipment

A flow-through extraction system contained within a space maintained at 37°C was constructed. This apparatus is shown diagramatically in Figure 1 and photographically in Figure 2. The outer dimensions are L 60cm x W 60cm x H 120cm.

The main structure of the box is wood and access to the extraction cells and other parts of the extraction system is through plexiglass doors on the fronts of both outer and inner box. The outer space is maintained between 35 and 39°C by a thermostatically controlled space heater with fan which operates on approximately 5 minute cycles. The inner box, which contains all of that part of the equipment where test material and lung fluid are in contact, is maintained at 37 $\pm$ 1°C. Thermometers, both in the air space and set in lung fluid solution in the inner box, monitor the temperature of the extraction process.

The extraction system consists of readily available, inexpensive components and is all-plastic. Other materials such as metal and glass were avoided because of potential corrosion, contamination and adsorption problems. Mixing of the test material and lung fluid is achieved through teflon coated iron stir bars.

As many as four extractions may be carried out simultaneously. For multichannel operation it is recommended that a four-position stir plate be used in order to achieve good mixing action.

2. Procedures

The preparation of simulated lung fluid is described in Appendix A.

Immediately prior to the extraction process, each ore sample was subjected to a pre-extraction wash by slurrying three times with approx. 100ml lung fluid and filtering over a 0.22um membrane filter. The wash was saved for analysis. The ore sample was washed off the filter into the extraction vessel.

The process of assembling the equipment, loading the sample, filling the lines and vessels with solution free of air-spaces and bubbles, and starting a satisfactory flow can only be achieved through individual practise and defies description. Once the sample is loaded and the flow established it becomes a simple matter of regularly monitoring temperature, gas flow-rate and solution flow-rate by visual inspection and input pH of the lung fluid in the reservoir by meter. The reservoir

solution must be adjusted to pH 7.25 with dilute hydrochloric acid at 12 hour intervals in order to maintain the input pH of the extraction in the range 7.25-7.45. The receiving vessels are removed and replaced as required. The collected fractions are immediately acidified by adding 1% of their volume of concentrated hydrochloric acid.

The flow of lung fluid is sustained by syphon action and the flow-rate can be varied between 0-2L per day by varying the vertical distance between the fixed lung fluid reservoir and the moveable receiving vessel. There are brackets on the inner wall of the outer box to facilitate this. Generally the flow-rate decreases during the course of an extraction process because of outlet filter blockage. This was not usually a problem in this work because lung fluid fraction periods were increased geometrically (1,2,4,8 days) while lung fluid fraction volumes were kept fairly constant. If it is desired to maintain a high flow-rate, the filter may be back-flushed occasionally by means of the syringe. In addition, the receiving vessel may be lowered (to floor level if necessary). In maintaining flow-rate it is also essential to charge the lung fluid reservoir every day with the day's requirement of lung fluid freshly filtered over a 0.2um membrane filter. The 0.45um filter on the outlet of the reservoir should also be changed every two to three days.

At the end of each extraction process involving an ore sample, the ore residue was recovered by washing out the extraction vessel, connecting lines, etc., with lung fluid and filtering the resulting slurry over a 0.22um membrane filter. Best efforts were made to make the recovery quantitative. The solution, usually about 300ml, was saved for analysis along with other lung fluid fractions. The ore residue was dried and saved for analysis comparative with the original material.

D. SUMMARY OF RESULTS AND DISCUSSION

1. General Remarks

For details of analysis results of individual test materials and lung fluid fractions, the reader is referred to the appendices of this report.

In the calculation of results for ore samples, where residues were recovered for analyses after extraction, all sample masses were adjusted for loss-on-ignition (LOI) at 550°C. The LOI was determined on a separate sample, not the analysed sample. The reasons for using LOI masses were to avoid hydration effects and to remove the effect of teflon particles in the ore residues arising from stir-bar abrasion.

In the extraction experiments on ore samples, 7 lung fluid fractions (including pre-extraction and post-extraction washes) were collected over a 16 day (384 hour) period. The timing of the flow fractions was as follows: 0-24h, 24-48h, 48-96h, 96-192h and 192-384h. The total volume of all fractions collected was 5-6 litres. The mass of ore used for the tests was about 2g.

In the processing of samples other than ores, no residues were collected and no pre- and post-extraction washes with lung fluid were carried out. The number of lung fluid fractions collected over the 16 day period was

five and the timing of these fractions was as outlined above for ore samples. The total volume of the lung fluid fractions collected was in the range 2-5L and varied from sample to sample.

2. Elliot Lake Uranium Ore

Summaries of results for the two particle-size fractions of Elliot Lake ore processed are presented in Tables 1 and 2. Uranium and radium are significantly extracted, whereas thorium, lead and polonium are not. Note the differences in concentrations of the various radionuclides between the two particle-size fractions in the original test materials.

The progresses of extractions over the 16 day period for these two samples are indicated in Figures 3 and 4 for elements where there are adequate data.

3. Mid-Western Uranium Ore

Summaries of results for the two particle-size fractions of Mid-Western ore processed are presented in Tables 3 and 4. Again, uranium and radium are significantly extracted, whereas thorium, lead and polonium are not. Large differences in radionuclide concentrations between particle-size fractions of the original test material again are apparent. There is a disequilibrium in the uranium-238 chain for the 53-75um test material. This is more apparent from the detailed analytical data given in Appendix C for this material.

The progresses of extractions over the 16 day period for these two samples are indicated in Figures 5 and 6 for elements where there are adequate data.

4. Neutron Activation Analysis of Uranium Ores

All of the uranium ores and their residues studied in this project were analysed by neutron activation analysis (NAA). Details of the methodology used are given in Appendix B. The NAA method was thought to be the best way of obtaining data on thorium-232 concentrations, but it was also recognized that information on stable elements and the general solubility behaviour of the ores could be gained this way.

The results of the NAA work are summarised in Table 5. It is obvious from the data that there is mineral fractionation according to particle size in the pulverisation process used to obtain these samples.

For the Mid-Western ore samples, it is also apparent that there is significant extraction of some stable elements in the processes applied.

5. Uranium Dioxide

The results of a 16 day extraction process applied to a 0.258g sample of unsintered uranium dioxide are summarised in Figure 7. There appears to be a fast solubility component followed by a period of fairly constant solubility rate. In total, 0.5% of the uranium in the original sample was extracted.

6. Uranium Trioxide

The results of a 16 day extraction process applied to a 0.292g sample of uranium trioxide are summarised in Figure 8. The material dissolves very quickly and this experiment was obviously carried out at far from ideal conditions. The sample should have been smaller and the flow-rate higher in order to avoid possible approach to saturation conditions. In total, 97% of the uranium in the original sample was extracted.

7. Yellow-Cake Aerosol

The results of a 16 day extraction process applied to the yellow-cake aerosol are summarised in Figure 9. Essentially 100% of the aerosol material dissolved, 80-90% dissolving within the first 24 hours.

8. Fuel Fabrication Plant Aerosol

The results of a 16 day extraction process applied to the fuel fabrication plant aerosol are summarised in Figure 10. There appears to be a fast solubility component followed by a period of fairly constant solubility rate. In total, 3% of the uranium on the original sample was extracted, 2% within the first 24 hours.

E RECOMMENDATIONS

1. General Remarks

The preceding summary of results indicates that a flexible system has been developed which has the capability of generating input data for lung dosimetry calculations. Sufficient information has been generated that sensible recommendations can be made on how the interactive components of the system should be integrated to optimize the quality of the data for each type of aerosol material, taking into account economic, technical and time constraints. Before putting these recommendations into effect, however, it would be useful to do further basic work towards a fuller understanding of the extraction processes and of the samples to be processed. These basic matters are discussed first.

2. Further Basic Study

2.1 Effect of pH

During the course of this work, questions have been raised on the matter of pH and its control. A specific criticism has been that once the lung fluid leaves the reservoir and enters the extraction system, the pH is out of control since there are no further measurements of pH until the lung fluid fractions are taken from the system. This is true, and the pH values of collected fractions are typically in the 7.6-8.6 range, but it is the observation of this author that lung fluid saturated with air/5% CO_2 is stable in the pH 7.3-7.4 range in closed systems, which is the case in this work until the fluid flow is beyond the filter at the outlet of the extraction cell.

Nevertheless, there remains the question of interaction between the lung fluid and the test material and its effect on pH. There are also the

questions of how critical a parameter is pH, and how tightly should it be controlled. An investigation of these matters would shed light on the pH question and perhaps ease experimental constraints.

2.2 Solubility Mechanisms

From the results of this and previous work in the field, it is difficult to determine the mechanisms which control the rate of removal of a particular chemical species from the test material matrix into solution and thence from the system. Is it simply a matter of chemical attack of the mineral structure(s) containing the species of interest? Or do co-precipitation and solution saturation play significant roles? The answer is probably that all three processes are significant to different degrees for different elements. There is probably also some sample dependence.

It would be possible to gain information in this area by injecting the extraction cells of runs in progress with true solutions of radioactive tracers of the elements under study and then measuring recovery in the lung fluid fractions.

2.3 Effect of Flow-Rate

An assumption has been made in this work that lung fluid flow-rate has no effect on solubility rates provided that sufficient lung fluid is supplied to maintain the concentrations of the chemical species under study at levels far below saturation conditions.

At the beginning of this work an attempt to prepare "saturated solutions" of the two uranium ore types studied was undertaken. This was done by immersing 25g samples of each of the ores in finely divided form in approximately 1L of lung fluid. The experiment was done in sealed polyethylene bottles. About once per week the contents of the bottles were thoroughly mixed and the pH was monitored.

After the first week, during which time there was a decrease of about 0.2 pH units in each solution, the pH tended to rise slowly but only needed adjusting at about monthly intervals with dilute hydrochloric acid to maintain it in the pH 7.3-7.4 range.

At the end of 3 months, these "saturated solutions" were analysed for U-238, Ra-226 and Th-232. The results of these analyses can be found at the back of Appendices D, F and I. It is apparent from these results, scanty though they are, that the concentrations of U-238, Ra-226 and Th-232 in some of the lung fluid fractions collected during the flow extraction experiments of this work were approaching the so-called "saturation" values. In retrospect, however, it is recognized that the method used to determine these "saturation" values is not valid.

The saturation values of interest should be determined for each species alone in solution to avoid confusion by such matters as rate of mineral attack and co-precipitation. It would not, in fact, be necessary to establish saturation values for most species, but merely to show that stable true solutions could be maintained at levels far above the concentrations encountered in extraction experiments. With such knowledge in hand, less conservative decisions could be made with regard to flow-rate/sample mass ratios.

This would help to keep the volumes of lung fluid collected to a minimum and therefore put less strain on the radioanalytical methodology used to determine the concentrations of the various extracted species.

It would also be useful to carry out experiments to compare the "decreasing flow-rate" approach (as used in this work) with the "constant flow-rate" approach in order to test the validity of the former.

2.4 Composition of Uranium Ores vs. Particle-Size

It is obvious from the data presented in Table 5 that the elemental and radionuclidic composition of the two uranium ores studied varies markedly between the two particle size fractions studied. Although not presented in this report, data on other particle size fractions of these ores confirm the trend of increasing radionuclidic content with decreasing particle-size.

It would be useful to carefully analyse ore fractions on cascade impactor stages to ascertain the situation with respect to particles of respirable size. Often in the past the assumption has been made that the composition of such particles reflects that of the bulk ore. Conclusions based on this assumption may be invalid. The potential radiotoxicity of respired and retained uranium ore particles may be greater or less than previously calculated.

3. Sampling

Sensitivities of the methods applied to the analysis of lung fluid fractions ultimately determine the sample sizes required for studies of specific aerosol types. Sample sizes then point to particular sampling methods.

It is put forward here that a sensitivity of 1% of the quantity of a radionuclide present in the original aerosol sample is sufficient to determine solubility behaviour to the degree required for lung dosimetry calculations.

With these points in mind, sample sizes and sampling methods are recommended below for specific cases. The sampling methodology is recommended considering that only the radionuclides uranium-238, uranium-235, uranium-234, thorium-232, thorium-230 and radium-226 are of major interest, reflecting current AECB thinking.

3.1 Uranium Ore Aerosols

If uranium nuclides only are of interest, an ore aerosol sample containing about 10ug uranium is adequate. An analytical sensitivity of 1% of this amount of uranium in 500ml lung fluid fractions is attainable before the blank value for uranium becomes unacceptable.

The above minimum uranium requirement indicates the need for 10mg samples of ores containing 0.1% uranium (e.g., Elliot Lake ores) and 1mg samples of ores containing 1% uranium (e.g., Mid-Western ores). The cascade impactor samplers currently used for routine air monitoring in the mines

and mills are capable of collecting these samples. For the Elliot Lake ores, considering current information on routine cascade impactor samples, modest extra effort would be required. Extended sampling times would be necessary, or samples and stages would need to be combined.

If thorium-230, radium-226 and thorium-232 are also of interest, the required sample size would be determined by the sensitivities of the radioanalytical methods for thorium-230 and radium-226 which would be applied to the lung fluid fractions. These methods would involve alpha-counting and would require 500ml lung fluid fractions to contain at least 0.005Bq of each activity. (Sub-samples of 100ml would be taken to determine each radionuclide). This would mean, applying the 1% criterion, that the original aerosol sample would need to contain 0.5Bq of both thorium-230 and radium-226.

The above argument indicates, for example, that 50mg samples for Elliot Lake ore and 5mg samples of Mid-Western ore would be needed. The Mid-Western ore samples could, again, be collected using the routine cascade impactor sampling methods, with modest extra effort. The Elliot Lake ore aerosols would appear to require special efforts for their collection. But it is recommended here that no departure from the cascade impactor method of sample collection be contemplated. In order to preserve sampling method consistency and particle-size information it would be best to push the methods already in place to the limit. It is further recommended, therefore, that work be carried out to determine the limitations of the routine cascade impactor method in collecting aerosols for solubility study purposes. The acceptability of combining samples from many cascade impactor runs would need to be addressed before such work is carried out. This author can see no objection to this concept. There would be no incompatibility with the extraction processes and analytical methods contemplated.

3.2 Refinery and Fuel Fabrication Plant Aerosols

For refinery and fuel fabrication plant aerosols, and the yellow cake processing areas of mills, only analysis for uranium is of interest for present purposes. It is recommended that the standard cascade impactor methods be used to collect aerosol samples from these areas. Each sample or impactor stage for study should have a minimum of 10ug uranium. Samples having uranium in the 50-100ug range would be optimum.

4. Extraction Methodology

It is recommended that the extraction equipment described in Section C be used essentially unchanged. Its mode of operation should also be unchanged, except for the volume and frequency of lung fluid fractions collected.

Bearing in mind the sample masses recommended in items 3.1 and 3.2 above, and the results of extraction runs presented in Section D, lung fluid fractions of about 500ml removed from the system at intervals of 1, 5, 10 and 30 days are recommended. Under these conditions it is not probable that the concentrations of solutes of interest will reach levels which influence rates of dissolution of further solute. It would, however, be prudent to pursue the recommendation of item 2.3 for further assurance on this point.

The lung fluid fraction intervals of 1, 5, 10 and 30 days have been chosen as the very minimum scientific requirement. It can be argued that more fractions are desirable, but economics militate against this for runs involving thorium-230, radium-226 and thorium-232 analyses in addition to uranium. Even with the four fractions recommended, most of the effort in such runs would be taken up by the required radiochemical analyses. It would, however, be possible to double (to eight) the number of fractions collected in runs involving only uranium-238 analyses with little economic impact.

5. Radiochemical Analyses

The radioanalytical methods used in this present work are outlined in Appendix B. For the analysis of lung fluid fractions, these methods may be used unchanged except that the method for radium-226 involving gamma-ray spectrometry should be displaced by a more sensitive method involving alpha-spectrometry. Descriptions of such methods abound in the literature and specifics need not be given here.

For analyses of the original test materials (aerosols, usually on glass-fibre filters), non-destructive methods would need to be used if collection of all samples in exact duplicate is to be avoided. There would seem to be three reasonable possibilities: neutron activation analysis (NAA), X-ray fluoresence analysis (XRF), and direct gamma-ray spectrometry (GRS). The relative merits of these methods will not be discussed here. However, it can be reasonably asserted that a combination of these readily available techniques are capable of yielding the requisite analytical data on original test materials without inflicting unacceptable damage.

F. TABLES AND FIGURES

Figures 1-10 referred to in the text are presented below on pages 10-15. Tables 1-5 appear on pages 16-20.

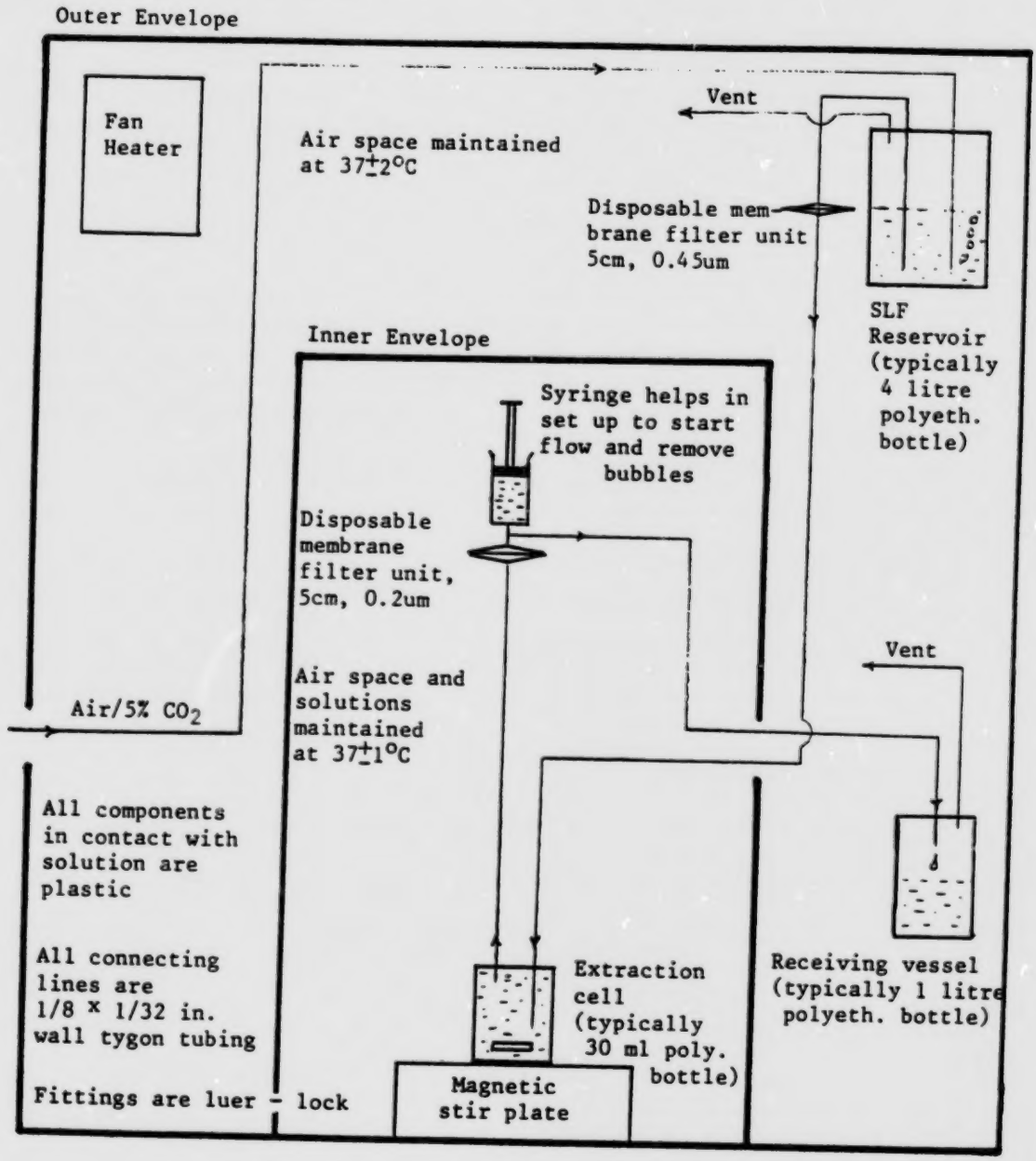
Outer Envelope
Fan Heater
Air space maintained at 37±2°C
Vent
Disposable membrane filter unit 5cm, 0.45um
SLF Reservoir (typically 4 litre polyeth. bottle)
Inner Envelope
Syringe helps in set up to start flow and remove bubbles
Disposable membrane filter unit, 5cm, 0.2um
Air space and solutions maintained at 37±1°C
Vent
Air/5% CO_2
All components in contact with solution are plastic
All connecting lines are 1/8 x 1/32 in. wall tygon tubing
Fittings are luer - lock
Extraction cell (typically 30 ml poly. bottle)
Magnetic stir plate
Receiving vessel (typically 1 litre polyeth. bottle)

FIGURE 1: Schematic Representation of Extraction Equipment

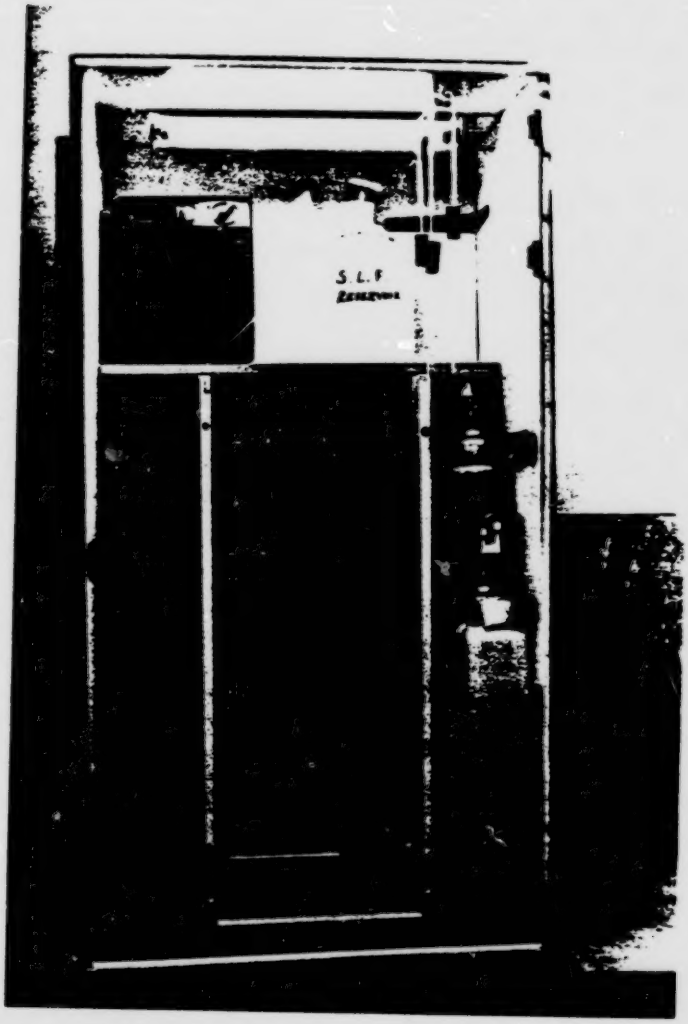

FIGURE 2: Photograph of Extraction Equipment

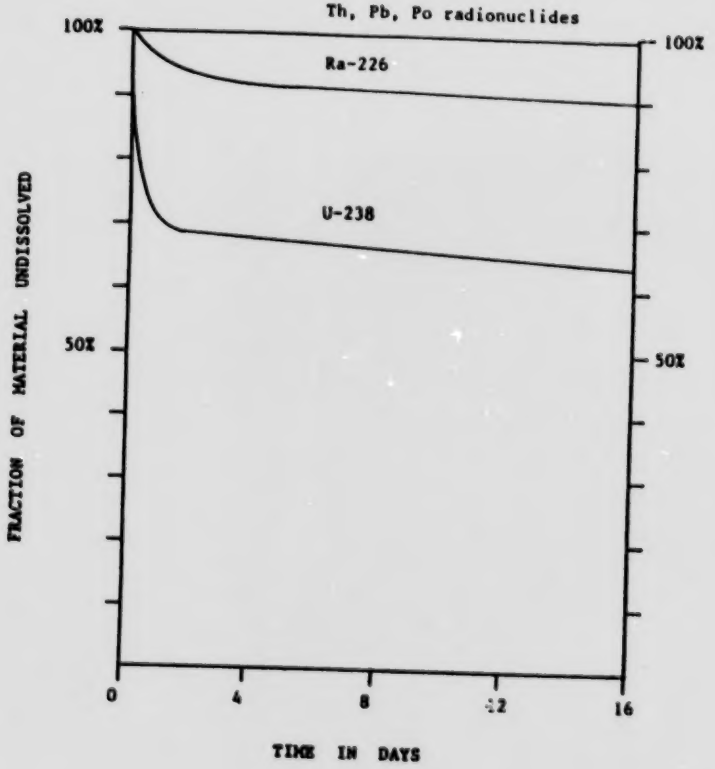

FIGURE 3: Approximate Extraction Progress
Elliot Lake Ore <38um

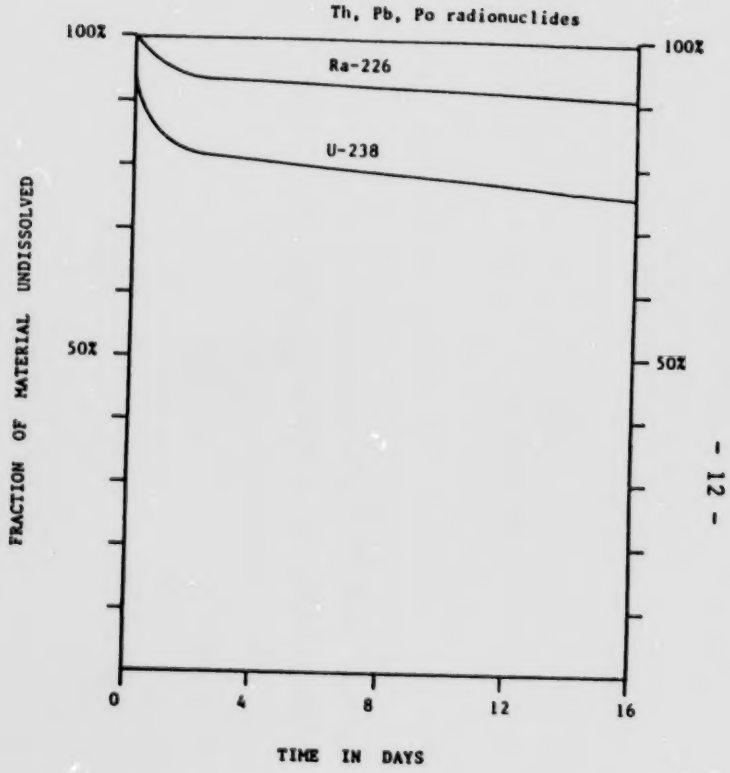

FIGURE 4: Approximate Extraction Progress
Elliot Lake Ore 53-75um

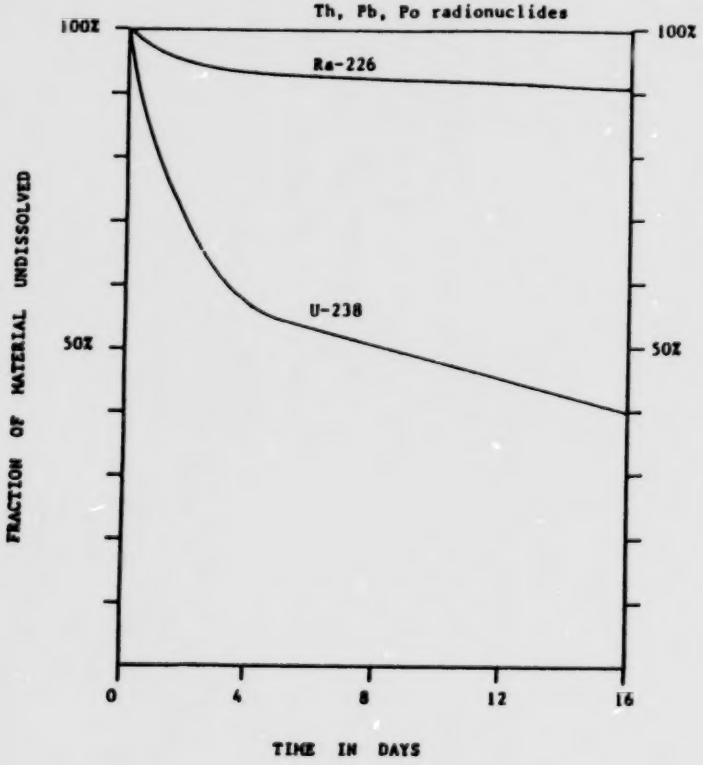

FIGURE 5: Approximate Extraction Progress
Mid-Western Ore ≤38um

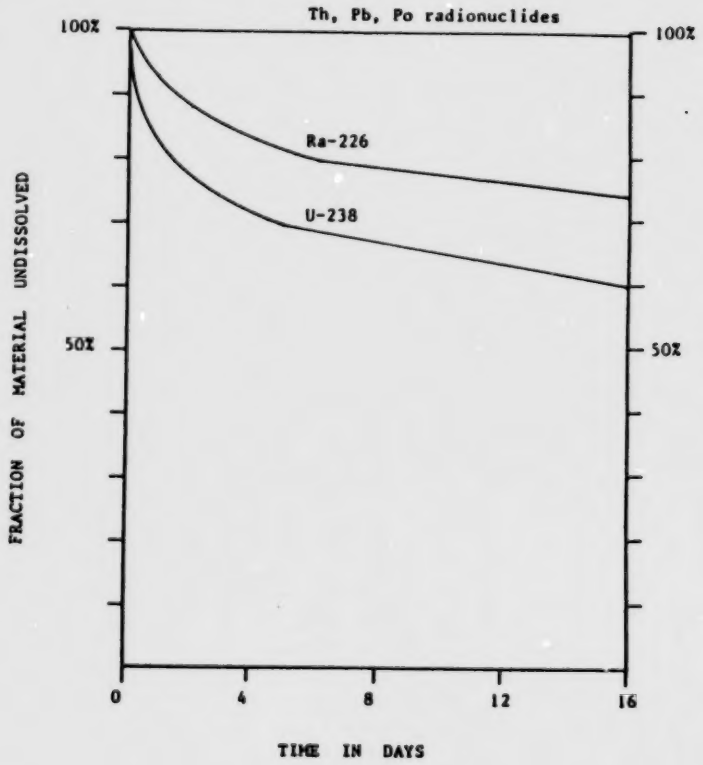

FIGURE 6: Approximate Extraction Progress
Mid-Western Ore 53-75um

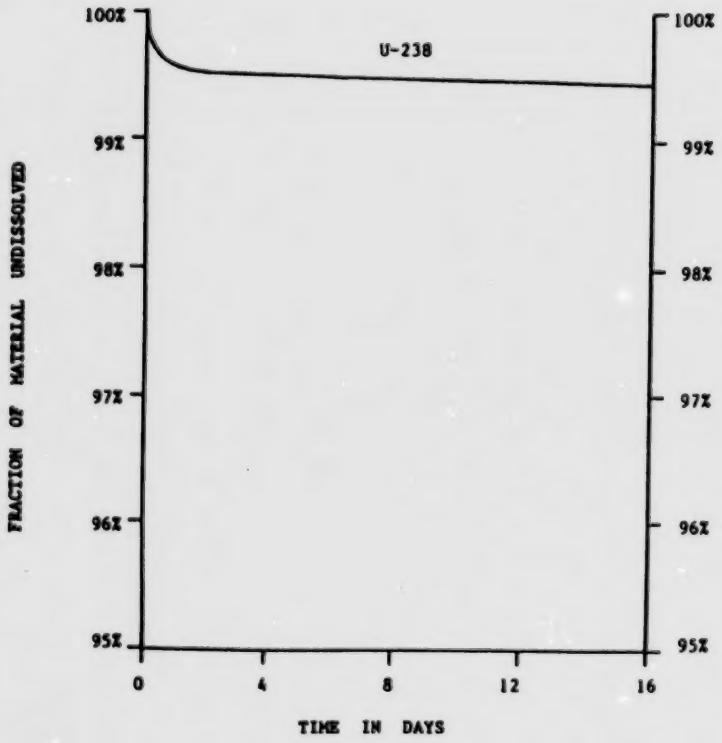

FIGURE 7: Approximate Extraction Progress
Uranium Dioxide ≤38um

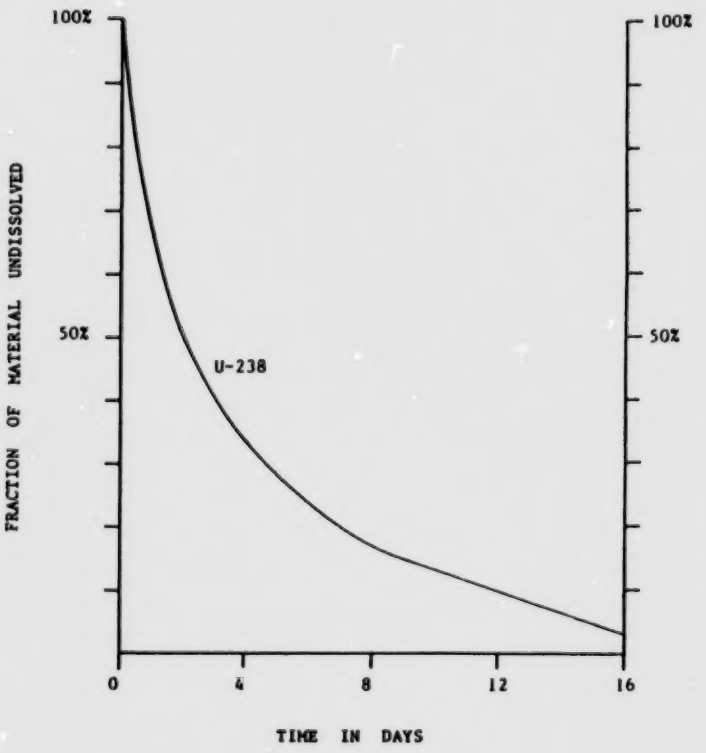

FIGURE 8: Approximate Extraction Progress
Uranium Trioxide ≤38um

(Note difference in scales
between Fig.7 and Fig.8)

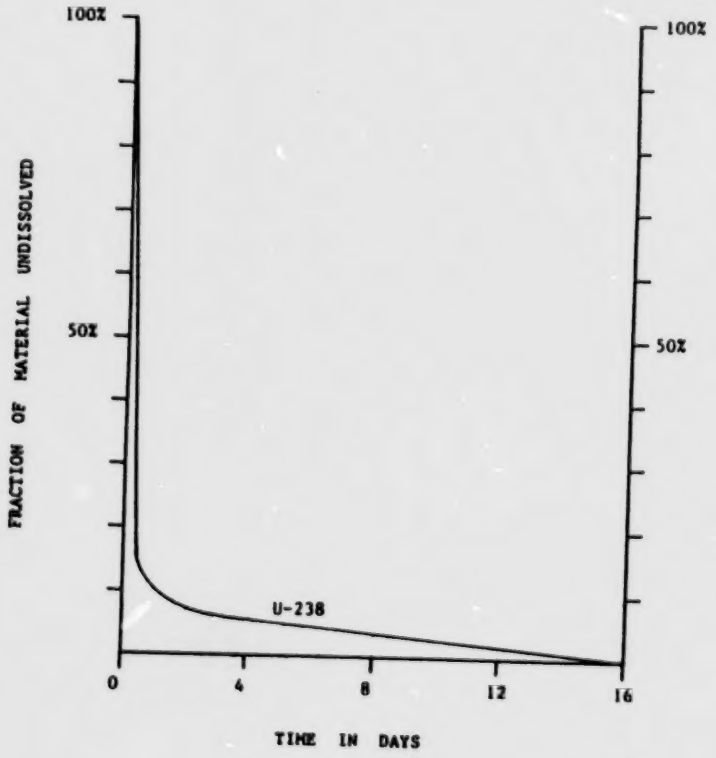

FIGURE 9: Approximate Extraction Progress
Yellow Cake Aerosol on Filter

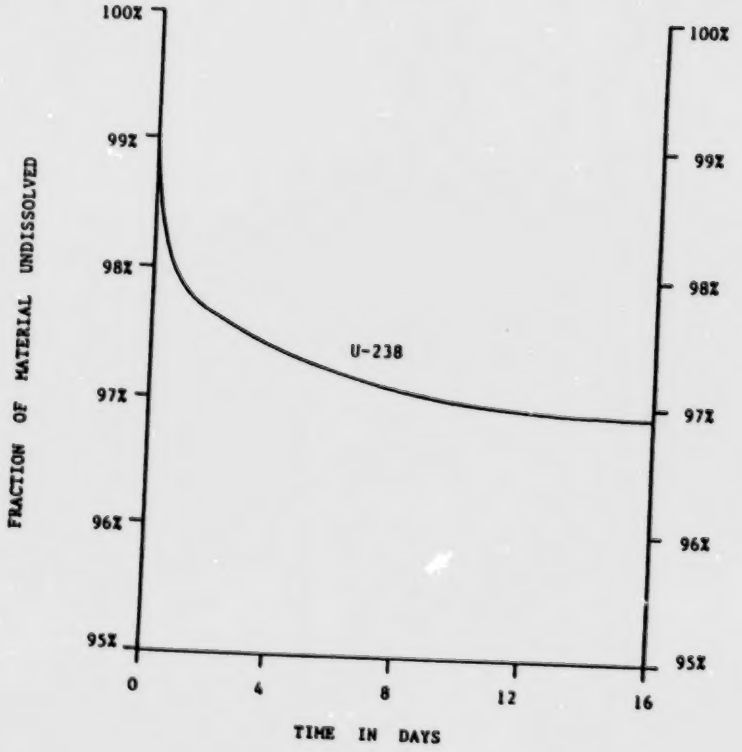

FIGURE 10: Approximate Extraction Progress
Fuel Fab. Plant Aerosol on Filter

(Note difference in scales
between Fig.9 and Fig.10)

Table 1: Summary of analysis results for original test material, residue of original test material and associated combined simulated lung fluid fractions collected over 16 days.

Test Material: Elliot Lake ore, 1.97g, ≤ 38 micron particles. (Recovered residue, 1.83g = 93% of original mass.)

Nuclide	Quantities of Nuclides Found		
	In Original Test Sample	In Recovered Residue of Test Sample	In Combined Simulated Lung Fluid Fractions
U-238	3070 ug (100%)	1990 ug (65%)	1100 ug (36%)
Th-230	37.6 Bq (100%)	32.8 Bq (87%)	0.2 Bq (<1%)
Ra-226	38.6 Bq (100%)	34.6 Bq (90%)	2.9-6.1 Bq (8-16%)
Pb-210	41.0 Bq (100%)	38.2 Bq (93%)	0.2 Bq (<1%)
Po-210	41.0 Bq (100%)	*	0.4 Bq (<1%)
Th-232	1840 ug (100%)	1590 ug (86%)	8-11 ug (<1%)
Ra-228	5.22 Bq (100%)	4.85 Bq (93%)	0-11 Bq (0-216%)

Notes:
1. * indicates "not determined".
2. The value for Po-210 in the test sample is inferred from Pb-210.
3. Weights of original sample and recovered residue are after adjustment for loss-on-ignition of separate samples at 550°C.

Table 2: Summary of analysis results for original test material, residue of original test material and associated combined simulated lung fluid fractions collected over 16 days.

Test Material: Elliot Lake ore, 1.96g, 53-75 micron particles. (Recovered residue, 1.93g = 98% of original mass.)

Nuclide	Quantities of Nuclides Found		
	In Original Test Sample	In Recovered Residue of Test Sample	In Combined Simulated Lung Fluid Fractions
U-238	1368 ug (100%)	1140 ug (84%)	333 ug (24%)
Th-230	17.9 Bq (100%)	15.9 Bq (89%)	0.1 Bq (< 1%)
Ra-226	16.7 Bq (100%)	13.7 Bq (82%)	1.4 Bq (8%)
Pb-210	17.5 Bq (100%)	15.7 Bq (90%)	0.1 Bq (< 1%)
Po-210	17.5 Bq (100%)	*	0.1 Bq (< 1%)
Th-232	764 ug (100%)	666 ug (87%)	2-5 ug (< 1%)
Ra-228	2.6 Bq (100%)	2.2 Bq (84%)	0-2.5 Bq (0-96%)

Notes:
1. * indicates "not determined".
2. The value for Po-210 in the test sample is inferred from Pb-210.
3. Weights of original sample and recovered residue are after adjustment for loss-on-ignition of separate samples at 550°C.

Table 3: Summary of analysis results for original test material, residue of original test material and associated combined simulated lung fluid fractions collected over 16 days.

Test Material: Mid-West ore, 1.87g, ≤ 38 micron particles.
(Recovered residue, 1.68g = 90% of original mass.)

Nuclide	Quantities of Nuclides Found		
	In Original Test Sample	In Recovered Residue of Test Sample	In Combined Simulated Lung Fluid Fractions
U-238	63400 ug (100%)	30200 ug (48%)	38100 ug (60%)
Th-230	726 Bq (100%)	702 Bq (97%)	2.4 Bq (< 1%)
Ra-226	770 Bq (100%)	654 Bq (85%)	67 Bq (9%)
Pb-210	763 Bq (100%)	734 Bq (96%)	2.0 Bq (< 1%)
Po-210	763 Bq (100%)	*	3.3 Bq (< 1%)
Th-232	142 ug (100%)	137 ug (97%)	< 19 ug (< 14%)
Ra-228	< 4 Bq	< 2 Bq	*

Notes:
1. * indicates "not determined".
2. The value for Po-210 in the test sample is inferred from Pb-210.
3. Weights of original sample and recovered residue are after adjustment for loss-on-ignition of separate samples at 550°C.

Table 4: Summary of analysis results for original test material, residue of original test material and associated combined simulated lung fluid fractions collected over 16 days.

Test Material: Mid-West ore, 1.98g, 53-74 micron particles.
(Recovered residue, 1.92g = 87% of original mass.)

	Quantities of Nuclides Found		
Nuclide	In Original Test Sample	In Recovered Residue of Test Sample	In Combined Simulated Lung Fluid Fractions
U-238	18500 ug (100%)	9220 ug (50%)	7400 ug (40%)
Th-230	236 Bq (100%)	271 Bq (115%)	1.4 Bq (< 1%)
Ra-226	175 Bq (100%)	124 Bq (71%)	45 Bq (26%)
Pb-210	172 Bq (100%)	181 Bq (105%)	0.9 Bq (< 1%)
Po-210	172 Bq (100%)	*	2.1 Bq (1.2%)
Th-232	26.7 ug (100%)	20.4 ug (76%)	1.1-8.6 (4-32%)
Ra-228	< 0.9 Bq	< 0.4	*

Notes:
1. * indicates "not determined".
2. The value for Po-210 in the test sample is inferred from Pb-210.
3. Weights of original sample and recovered residue are after adjustment for loss-on-ignition of separate samples at 550°C.

Table 5: Summary of results of neutron activation analyses of uranium ores and their residues.

Elliot Lake Ore Samples

	Original Ore ≤ 38 um	Ore Residue ≤ 38 um	Original Ore 53-75 um	Ore Residue 53-75 um
Uranium (ppm)	1,560	1,000	850	580
Thorium (ppm)	930	870	390	340
Cobalt (ppm)	51	47	60	61
Silicon (%)	36	33	41	38
Aluminum (%)	4.6	5.1	3.6	3.2

Mid-Western Ore Samples

	Original Ore ≤ 38 um	Ore Residue ≤ 38 um	Original Ore 53-75 um	Ore Residue 53-75 um
Uranium (%)	3.09	1.55	0.85	0.46
Thorium (ppm)	76	82	14	16
Antimony (ppm)	110	59	22	7
Arsenic (%)	5.0	2.9	0.94	0.25
Nickel (%)	2.4	1.3	0.45	0.07
Cobalt (%)	0.31	0.26	0.05	0.02
Aluminum (%)	4.6	5.8	2.4	2.8

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APPENDIX A

SIMULATED LUNG FLUID

Simulated lung fluid was prepared in 10L batches by adding the ingredients listed below in order to approximately 9L distilled water in a polyethylene container. Each reagent was dissolved with stirring before the next was added. The final volume was made to be 10L with distilled water and then the solution was saturated with air/5% CO_2. Finally the solution was adjusted to pH 7.3-7.4 with small volumes of 1N HCl before being stored refrigerated.

Daily requirements were taken from this stored supply, vacuum filtered over a 47mm 0.25um membrane filter, resaturated with air/5% CO_2 and re-adjusted to pH 7.25 before use in extraction processes.

The refrigerated, stored supply of simulated lung fluid became increasingly difficult to filter with the passage of time. The typical lifetime of such a 10L supply was 1 week. Any solution older than 1 week was discarded.

Simulated lung fluid ingredients to make 10L:

	Chemical Formula	Mass	Name	Fisher Scientific Catalogue Number
1.	$MgCl_2 \cdot 6H_2O$	2.03 g	Magnesium chloride	M-33
2.	NaCl	60.02 g	Sodium chloride	S-271B
3.	KCl	2.98 g	Potassium chloride	P-217
4.	Na_2HPO_4	1.42 g	Sodium phosphate	S-374
5.	Na_2SO_4	0.71 g	Soduim sulphate	S-421
6.	$CaCl_2 \cdot 2H_2O$	3.68 g	Calcium chloride	C-79
7.	$NaH_3C_2O_2$	5.74 g	Sodium acetate	S-210
8.	$NaHCO_3$	26.04 g	Sodium bicarbonate	S-233B
9.	$Na_3H_3C_6O_7 \cdot 2H_2O$	0.97 g	Sodium citrate	S-279

All of the above chemicals were certified ACS grade except No. 9 which was Fisher certified.

The formulation and preparation are similar to those used in previous work[3,4,5,11,12].

RADIOANALYTICAL METHODS

1. Gamma-Ray Spectrometry

1.1 Analyses of uranium ores and residues for U-238, Th-230, Ra-226, Pb-210 and Ra-228

Samples of approximately 1g of finely divided, dry ores and residues were doubly packaged in flat, polyethylene bags. The polyethylene bags were formed of heat-sealed 0.01cm thick material. The inner bag was approximately 2.5cm square and the outer bag approximately 2.8cm square. Air was squeezed from the bags before heat-sealing so that a perfectly flat package was formed.

This method of packaging was devised for this project for small solid samples to maximize counting efficiency and to minimize attenuation of low energy gamma-rays, particularly those of Th-234 (63.3keV), Th-230 (67.6keV) and Pb-210 (46.5keV). The bagged samples were directly counted for periods up to 24h on the flat horizontal aluminum window of a shielded high-resolution germanium gamma-ray detector. The construction materials of this counting system had been selected for low count-rate applications. The results of these measurements are given in detail in Appendix C, including data on certified reference materials. A computer program developed for this project was used to reduce the spectral data and calculate and print the final results.

It is noted here that the above counting methodology is not suitable for the determination of radium-226 through the gamma-rays emitted by its daughter products, if there is significant escape of Rn-222 from the sample matrix into the interstitial air space within the inner bag. Such released Rn-222 rapidly leaks through and out of the polyethylene packaging, leaving a variable and unknown deficit in Pb-214 and Bi-214 build-up. Some of the ore samples used in this work were affected this way. For this reason Ra-226 measurements on ore samples were based on its own 186.2keV gamma-ray, with correction for U-235 (185.7keV) according to the measured value for U-238. The correction necessitated assumption of the "natural" isotopic ratio for U-238/U-235.

1.2 Analyses of Lung Fluid Fractions for Ra-226 and Ra-228

Approximately 15% of each lung fluid fraction collected in uranium ore extractions was analysed for Ra-226 and Ra-228.

To a volume of cold, acidified lung fluid in the range 50-150ml in a 150ml glass beaker was added 50mg barium as $BaCl_2$ solution. The solution was stirred and 1ml concentrated sulphuric acid was added dropwise with stirring. The solution and precipitated $BaSO_4$ were allowed to sit overnight before stirring and vacuum filtering over a 25mm 0.45um membrane filter (Durapore by Millipore) were carried out. The precipitate was washed with 5ml 0.1% H_2SO_4 and allowed to air dry.

The precipitate and filter were then doubly packaged in polyethylene bags as described in item 1.1 above. In this case, leakage of Rn-222 from the packaging was not a problem since only negligible amounts of Rn-222 escape from the $BaSO_4$ matrix. This allowed determination of Ra-226 through the gamma-rays of its daughters Pb-214 and Bi-214 after a suitable build-up period. Counting was as described in item 1.1 above for periods 8-24h.

The validity of this approach was borne out by the results reported in Appendix F. Where there are results above detection limits for Ra-226 via both is own gamma-ray (186.2keV) and those of its daughter products (351.9, 295.2, 609.0keV), agreement is good.

The chemical separation method was checked using Ra-224 tracer prepared as needed by separation from a supply of Th-228. Chemical yields for four tracer experiments lay in the range 86-93%. A 90% yield factor was applied to the real analyses. All spectral data reduction, calculations and report printing was carried out through a computer program developed for this project.

It is noted here that there appears to be negligible interference with this method via co-precipitation of uranium and thorium species which generally were present at higher activity levels than radium at the time of analysis of lung fluid fractions.

It is also noted that the sensitivity of this method was marginal in providing data of adequate quality in this work. The method will certainly need to be discarded in favour of an alpha-counting method for Ra-226 if the sample size and other recommendations of Section E of this report are put into effect.

2. Alpha-Spectrometry

2.1 Analyses of Lung Fluid Fractions for Th-230

Approximately 10% of each lung fluid fraction collected in uranium ore extractions was analyzed for Th-230.

To a volume of cold acidified lung fluid in the range 30-100ml in a 150ml glass beaker was added 5mg Fe^{3+} carrier plus 2ml of a 5% solution of 8-hydroxyquinoline (oxine) in methanol. The solution was stirred and adjusted to pH7 with 25% ammonium hydroxide solution. The solution and precipitated iron oxinate with carried uranium and thorium was filtered over a 25mm 0.45um membrance filter (MF by Millipore). The precipitate was washed on the filter with 5ml 0.05% oxine in water. The filter and precipitate were dried at 110°C wetted with 1 drop conc. HNO_3 and then placed in a 30ml porcelain crucible and slowly ashed at 550°C in a furnace. The ash was dissolved in 5ml 8N HCl and the solution was passed over a 1 x 3cm anion exchange column (AG1 x 8 100-200 mesh chloride form, Bio-Rad Laboratories) which adsorbed uranium and iron as chloro-complexes. The column was washed free of thorium with a further 5ml 8N HCl.

The eluate and wash were combined in a 50ml polymethylpentene (PMP) beaker and evaporated almost to dryness. At this stage 10ml water, 100ug

La carrier and 1ml 48% HF were added and the solution was stirred and placed in a refrigerator at 0°C for 1 hour. The solution was then vacuum filtered over a 25mm 0.22um membrane filter (Durapore by Millipore) which had just previously been prepared by filtering a similarly prepared but inactive LaF_3 precipitate. The filter and precipitate were washed with 5ml methanol, allowed to dry at room temperature and then mounted on silver disc backings for alpha-counting.

Tests of this separation method using Th-234 tracer gave recoveries of 74-88% in 4 trials. A yield factor of 80% was applied to the real analyses. The LaF_3 precipitation method is essentially that according to Joshi[13].

Alpha-spectrometry was carried out under vacuum via 8-24h counts using a $400mm^2$ silicon detector with source-detector distance about 2cm. The alpha-particle complex at 4.6-4.7MeV was used to estimate Th-230 activity. Calculations were manual. Calibration of the detection system was carried out using a Ra-226 alpha source (195Bq) traceable to the U.S. National Bureau of Standards (NBS).

2.2. Analyses of Lung Fluid Fractions for Pb-210

Approximately 10% of each lung fluid fraction collected in uranium ore extractions was analyzed for Pb-210.

To 30-100ml aliquots of cold acidified lung fluid fractions in 150ml polymethylpentene beakers was added 5mg Pb^{2+} carrier and 1ml conc. HCl. With continuous stirring, 1ml conc. ammonium sulphide was added to the solution to precipitate PbS. After a digestion period of 30-60min. the precipitate was filtered over a 47mm 0.45um membrance filter (Durapore by Millipore) which was then washed with 5-10ml water. The filter receiving vessel was then changed and the filter was wetted with portions of 1:1 conc. HCl/HNO_3 to dissolve PbS. Each portion was pulled through the filter after a period of a few minutes in contact with the precipitate. In all, 5ml of the acid mixture wash was used. Finally the filter was washed with 5ml water which was combined with the acid wash. The solution containing Pb-210 was then evaporated almost to dryness in a 50ml polymethylpentene beaker.

The residue in the beaker was taken up with 5ml 1.5N HCl and passed over a 1 x 3cm anion exchange column (AG1 x 8 100-200 mesh chloride form, Bio-Rad Laboratories). The beaker and column were washed with 10ml 1.5N HCl. Lead-210 was eluted from the column with 20ml 0.1N HCl into a 50ml polyethylene bottle which was then capped for a period of at least 6 weeks to allow significant in-growth of the Po-210 daughter. The Po-210 was then auto-plated onto silver discs with Po-208 as tracer and counted as described under the method for Po-210 below in this appendix. The concentration of Pb-210 in the original lung fluid sample was manually calculated from the measured Po-210 activity.

Tests of the Pb separation to the point of solution storage for Po-210 generation using Pb-212 as tracer gave yields of 82-90% in four trials. A yield factor of 85% was applied to real runs as well as a correction for Po-208 tracer recovery in the plating process which was typically about 70%.

2.3 Analyses of Lung Fluid Fractions for Po-210

Approximately 10% of each lung fluid fraction collected in uranium ore extractions was analysed for Po-210. The analyses were carried out immediately each fraction was collected to avoid in-growth of Po-210 from Pb-210.

To 30-100ml aliquots of cold acidified lung fluid fractions in 150ml polymethylpentene beakers was added 0.25g sodium sulfite and a weighed portion of Po-208 tracer solution. A magnetic, teflon-coated stir-bar and a 0.02 x 2.8cm silver disc (masked with laquer on the down side) were placed in the beaker which was then covered with a watchglass and placed on a stirrer-hotplate. With slow stirring and temperature maintained at 60-70°C, plating of Po-210 was allowed to proceed for 24 hours.

Alpha-counting of the discs was done under vacuum using a 400mm^2 silicon detector. Source-detector distance was approximately 2cm and count periods were in the range 8-24h. The system was calibrated using a Ra-226 alpha source (195 Bq) traceable to NBS. Reduction of spectral data was done manually. The alpha peaks at 5.30 and 5.12MeV were used to estimate Po-210 and Po-208 respectively. Decay corrections were made back to the time the lung fluid fractions were collected.

3. Neutron Activation Analysis

3.1 Analyses of Uranium Ores and Residues for Al, Si, Co, Ni, As, Sb, Th and U

Samples in the range 0.3-1g were irradiated under cadmium in order to suppress uranium fission which gives rise to fission products causing spectral interferences and high background in the gamma-ray spectra.

Aluminum and silicon were determined through (n,γ) and (n,p) reactions respectively using a 2 minute epi-Cd irradiation (thermal flux 10" n cm^{-2} s^{-1}) in the SLOWPOKE reactor of the University of Toronto. After a decay period of 10 minutes, gamma-ray spectra were acquired using a germanium detector fitted with a Pb/Cd/Cu absorber to suppress the 75keV signal of U-239. The intensities of the gamma-lines at 1779keV (Al-28) and 1274keV (Al-29) were used to estimate Al and Si concentrations respectively. Calibration of the system was carried out through analyses of several certified reference materials.

Uranium, thorium, antimony, arsenic, cobalt and nickel were determined through 15 minute epi-Cd irradiations (thermal flux 5 x 10^{12} n cm^{-2} s^{-1}) at the PULSTAR reactor of the State University of New York at Buffalo. All of the nuclear reactions used were (n,γ) except for nickel (n,p). After a decay period of 2 weeks, gamma-ray spectra were acquired using a germanium detector. The intensities of the gamma-lines at 277keV (Np-239), 312keV (Pa-233), 564keV (Sb-122), 559keV(As-76), 1332keV (Co-60) and 811keV (Co-58) were used to estimate concentrations for U, Th, Sb, As, Co and Ni respectively. Calibration of the system was carried out through analyses of several certified reference materials.

3.2 Analyses of Lung Fluid Fractions for U-238 and Th-232

Lung fluid aliquots varying in volume in the range 1-10% of collected lung fluid fractions were analyzed for U-238 and Th-232 together by neutron activation.

The uranium and thorium were co-precipitated on aluminum oxinate as follows. To the acidified lung fluid aliquot (diluted if necessary to at least 50ml) in a 150 ml beaker was added 2mg Al^{3+} carrier and 2ml of 5% 8-hydroxquinoline (oxine) solution in methanol. The solution was stirred and adjusted to pH 7 with 25% ammonium hydroxide solution. The precipitate was filtered over a 25mm 0.45um membrane filter (MF by Millipore). The filter and precipitate were washed with 5ml 0.05% oxine solution in water and then allowed to air dry before being packaged for neutron irradiation. Yields of the co-precipitation process lay in the range 93-98% for uranium and thorium in 4 trials using known amounts of each element. A yield factor of 95% was applied to real analyses.

The prepared samples were irradiated at a neutron flux of 2.5×10^{11} n cm^{-2} s^{-1} for 16h in the SLOWPOKE reactor at the University of Toronto. After a decay period of 2-3 days the samples were counted for 15 minutes each for uranium using a computerized gamma-ray spectrometer with germanium detector. A similar count for thorium was carried out after a further decay period of 3 weeks. The uranium and thorium estimates were made through the 277keV and 312keV gamma-lines of Np-239 and Pa-233 respectively. Spectral data reduction and reporting were performed via a computer program written for this project. Calibration of the system was carried out using several reference materials certified for uranium and thorium.

APPENDIX C

ANALYSIS RESULTS: GAMMA-RAY SPECTROMETRY OF URANIUM ORES AND RESIDUES FOR U-238, Th-230, Ra-226, Pb-210 AND Ra-226

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: ELLIOT LAKE ORE <38UM PARTICLES
SAMPLE MASS: .984 GRAMS
COUNT PERIOD: 64800 SECONDS
COUNT DAY: 6 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	19.2	BQ/G	RSD=5.1 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	19.1	BQ/G	RSD=17.4 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	19.6	BQ/G	RSD=5.7 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	20.8	BQ/G	RSD=5.2 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	2.65	BQ/G	RSD=8.8 %
VIA AC-228(969.1KEV)	2.64	BQ/G	RSD=12.6 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	3.26	BQ/G	RSD=4.5 %
VIA TL-208(583.1KEV)	3.3	BQ/G	RSD=6.9 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	19.2	BQ/G	RSD=5.1 %
THORIUM-230	19.1	BQ/G	RSD=17.4 %
RADIUM-226	19.6	BQ/G	RSD=5.7 %
LEAD-210	20.8	BQ/G	RSD=5.2 %
RADIUM-228	2.65	BQ/G	RSD=7.2 %
THORIUM-228	3.27	BQ/G	RSD=3.8 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	1560	PPM	RSD=5.1 %

BECQUEREL LABORATORIES INC.
AECB PROJECT SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES U, INTERNALLY IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY

SAMPLES OF AERIAL, IN WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: ELLIOT LAKE ORE RESIDUE SRUM PARTILLES

SAMPLE MASS: 9 GRAMS

COUNT PERIOD: 72000 SECONDS

COUNT DAY: 75 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	13.4	BQ/G	RSD=5.7 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	17.9	BQ/G	RSD=18 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	18.9	BQ/G	RSD=5.5 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	20.9	BQ/G	RSD=5.2 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	2.47	BQ/G	RSD=8.7 %
VIA AC-228(969.1KEV)	2.94	BQ/G	RSD=11.1 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	3.31	BQ/G	RSD=4.4 %
VIA TL-208(583.1KEV)	3.28	BQ/G	RSD=6.8 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	13.4	BQ/G	RSD=5.7 %
THORIUM-230	17.9	BQ/G	RSD=18 %
RADIUM-226	18.9	BQ/G	RSD=5.5 %
LEAD-210	20.9	BQ/G	RSD=5.2 %
RADIUM-228	2.65	BQ/G	RSD=6.8 %
THORIUM-228	3.3	BQ/G	RSD=3.7 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	1090	PPM	RSD=5.7 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SUITABILITY OF MATERIALS IN SIMULATE [illegible]

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL:	ELLIOT LAKE ORE 53-75UM PARTICLES	
SAMPLE MASS:	.9P	GRAMS
COUNT PERIOD:	720000	SECONDS
COUNT DAY:	100	JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	8.57	BQ/G	RSD=6.2 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	9.13	BQ/G	RSD=24.5 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	8.54	BQ/G	RSD=7.2 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	8.95	BQ/G	RSD=6.7 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	1.26	BQ/G	RSD=11.5 %
VIA AC-228(969.1KEV)	1.42	BQ/G	RSD=15.7 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	1.35	BQ/G	RSD=5.4 %
VIA TL-208(583.1KEV)	1.26	BQ/G	RSD=9.9 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	8.57	BQ/G	RSD=6.2 %
THORIUM-230	9.13	BQ/G	RSD=24.5 %
RADIUM-226	8.54	BQ/G	RSD=7.2 %
LEAD-210	8.95	BQ/G	RSD=6.7 %
RADIUM-228	1.32	BQ/G	RSD=9.3 %
THORIUM-228	1.33	BQ/G	RSD=4.7 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	696	PPM	RSD=6.2 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: ELLIOT LAKE ORE RESIDUE 53-75UM PARTICLES
SAMPLE MASS: .721 GRAMS
COUNT PERIOD: 72000 SECONDS
COUNT DAY: 99 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV) 7.3 BQ/G RSD=7.3 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV) 8.25 BQ/G RSD=29.2 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV) 7.1 BQ/G RSD=8.8 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV) 8.16 BQ/G RSD=7.8 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV) 1.14 BQ/G RSD=13.9 %
VIA AC-228(969.1KEV) 1.1 BQ/G RSD=21.3 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV) 1.35 BQ/G RSD=5.8 %
VIA TL-208(583.1KEV) 1.25 BQ/G RSD=11.2 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	7.3	BQ/G	RSD=7.3 %
THORIUM-230	8.25	BQ/G	RSD=29.2 %
RADIUM-226	7.1	BQ/G	RSD=8.8 %
LEAD-210	8.16	BQ/G	RSD=7.8 %
RADIUM-228	1.13	BQ/G	RSD=11.6 %
THORIUM-228	1.33	BQ/G	RSD=5.2 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	593	PPM	RSD=7.3 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA RAY SPECTROMETRY.

SAMPLES OF APPROX. 10 WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR

MATERIAL: MID-WEST ORE (SUBUM PARTICLES
SAMPLE MASS: .92± GRAMS
COUNT PERIOD: 72000 SECONDS
COUNT DAY: 367 JULIAN 1985

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	417	BQ/G	RSD=3.4 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	388	BQ/G	RSD=5.6 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	412	BQ/G	RSD=3.5 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	408	BQ/G	RSD=3.4 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	1.81	BQ/G	RSD=26.6 %
VIA AC-228(969.1KEV)	-2.12	BQ/G	RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	.332	BQ/G	RSD=31 %
VIA TL-208(583.1KEV)	-.902	BQ/G	RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	417	BQ/G	RSD=3.4 %
THORIUM-230	388	BQ/G	RSD=5.6 %
RADIUM-226	412	BQ/G	RSD=3.5 %
LEAD-210	408	BQ/G	RSD=3.4 %
RADIUM-228	1.81	BQ/G	RSD=26.6 %
THORIUM-228	.332	BQ/G	RSD=31 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	33900	PPM	RSD=3.4 %

RECOVERY LABORATORIES INC.
AEC PROJECT SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: MID-WEST ORE RESIDUE (3BUM PARTICLES
SAMPLE MASS: 922 GRAMS
COUNT PERIOD: 72000 SECONDS
COUNT DAY: 160 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV) 221 BQ/G RSD=3.6 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV) 418 BQ/G RSD=5.3 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV) 389 BQ/G RSD=3.5 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV) 437 BQ/G RSD=3.4 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV) -1.1 BQ/G RSD=0 %
VIA AC-228(969.1KEV) -1.91 BQ/G RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV) .308 BQ/G RSD=32.2 %
VIA TL-208(583.1KEV) -.815 BQ/G RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	221	BQ/G	RSD=3.6 %
THORIUM-230	418	BQ/G	RSD=5.3 %
RADIUM-226	389	BQ/G	RSD=3.5 %
LEAD-210	437	BQ/G	RSD=3.4 %
RADIUM-228	-1.1	BQ/G	RSD=0 %
THORIUM-228	.308	BQ/G	RSD=32.2 %

URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS:
FROM U-238 18000 PPM RSD=3.6 %

RECOUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOIL SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: MID-WEST ORE 53-75UM PARTICLES
SAMPLE MASS: .99 GRAMS
COUNT PERIOD: 28800 SECONDS
COUNT DAY: 107 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV) 115 BQ/G RSD=4.1 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV) 119 BQ/G RSD=9.7 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV) 88.6 BQ/G RSD=4.9 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV) 87 BQ/G RSD=4.6 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV) -.94 BQ/G RSD=0 %
VIA AC-228(969.1KEV) -1.69 BQ/G RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV) -.205 BQ/G RSD=0 %
VIA TL-208(583.1KEV) -.712 BQ/G RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	115	BQ/G	RSD=4.1 %
THORIUM-230	119	BQ/G	RSD=9.7 %
RADIUM-226	88.6	BQ/G	RSD=4.9 %
LEAD-210	87	BQ/G	RSD=4.6 %
RADIUM-228	-.94	BQ/G	RSD=0 %
THORIUM-228	-.205	BQ/G	RSD=0 %

URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS:
FROM U-238 9350 PPM RSD=4.1 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 15 WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: MID-WEST ORE RESIDUE 53-75UM PARTICLES
SAMPLE MASS: .442 GRAMS
COUNT PERIOD: 720.0 SECONDS
COUNT DAY: 102 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	59	BQ/G	RSD=4.4 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	141	BQ/G	RSD=6.2 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	64.6	BQ/G	RSD=4.7 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	94.3	BQ/G	RSD=3.8 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-.412	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-.736	BQ/G	RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	-.0953	BQ/G	RSD=0 %
VIA TL-208(583.1KEV)	-.311	BQ/G	RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	59	BQ/G	RSD=4.4 %
THORIUM-230	141	BQ/G	RSD=6.2 %
RADIUM-226	64.6	BQ/G	RSD=4.7 %
LEAD-210	94.3	BQ/G	RSD=3.8 %
RADIUM-228	-.412	BQ/G	RSD=0 %
THORIUM-228	-.0953	BQ/G	RSD=0 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	4800	PPM	RSD=4.4 %

BECQUEREL LABORATORIES LTD.
AECB PROJECT - SOLUBILITY OF URANIUM OXIDE IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 10 TO 40 CM ARE CHUNK - ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR

MATERIAL: URANIUM DIOXIDE FLUID BED ELDORADO, .36UM PARTICLES
SAMPLE MASS: .127 GRAMS
COUNT PERIOD: 2400 SECONDS
COUNT DAY: 5 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV) 9750 BQ/G RSD=3.9 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV) -873 BQ/G RSD=0 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV) -296 BQ/G RSD=0 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV) -139 BQ/G RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV) -52.6 BQ/G RSD=0 %
VIA AC-228(969.1KEV) -69.5 BQ/G RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV) -8.35 BQ/G RSD=0 %
VIA TL-208(583.1KEV) -40.9 BQ/G RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	9750	BQ/G	RSD=3.9 %
THORIUM-230	-873	BQ/G	RSD=0 %
RADIUM-226	-296	BQ/G	RSD=0 %
LEAD-210	-139	BQ/G	RSD=0 %
RADIUM-228	-52.6	BQ/G	RSD=0 %
THORIUM-228	-8.35	BQ/G	RSD=0 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	793000	PPM	RSD=3.9 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 10 MG WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: UO2(NO3)2 ON ISOTOXIDE, ELDORADO, <38UM PARTICLES
SAMPLE MASS: .134 GRAMS
COUNT PERIOD: 6000 SECONDS
COUNT DAY: 96 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	8830	BQ/G	RSD=3.6 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	-525	BQ/G	RSD=0 %

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	495	BQ/G	RSD=15.8 %

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	-87.8	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-30.9	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-53.6	BQ/G	RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	-5.1	BQ/G	RSD=0 %
VIA TL-208(583.1KEV)	-24.7	BQ/G	RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	8830	BQ/G	RSD=3.6 %
THORIUM-230	-525	BQ/G	RSD=0 %
RADIUM-226	495	BQ/G	RSD=15.8 %
LEAD-210	-87.8	BQ/G	RSD=0 %
RADIUM-228	-30.9	BQ/G	RSD=0 %
THORIUM-228	-5.1	BQ/G	RSD=0 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	718000	PPM	RSD=3.6 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: DH-1A STANDARD REFERENCE MATERIAL (CANMET, OTTAWA)
SAMPLE MASS: .997 GRAMS
COUNT PERIOD: 72000 SECONDS
COUNT DAY: 361 JULIAN 1985

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	32.1	BQ/G	RSD=4.5 %	

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	29.4	BQ/G	RSD=14.1 %	

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	32	BQ/G	RSD=4.9 %	**(31.5 Cert.)**

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	30.8	BQ/G	RSD=4.8 %	**(30.8 Cert.)**

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	3.73	BQ/G	RSD=7.7 %
VIA AC-228(969.1KEV)	3.28	BQ/G	RSD=11.8 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	3.87	BQ/G	RSD=4.4 %
VIA TL-208(583.1KEV)	3.97	BQ/G	RSD=6.6 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	32.1	BQ/G	RSD=4.5 %
THORIUM-230	29.4	BQ/G	RSD=14.1 %
RADIUM-226	32	BQ/G	RSD=4.9 %
LEAD-210	30.8	BQ/G	RSD=4.8 %
RADIUM-228	3.6	BQ/G	RSD=6.4 %
THORIUM-228	3.9	BQ/G	RSD=3.7 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	2610 **(2629 Cert.)**	PPM	RSD=4.5 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL:	BL-5 STANDARD REFERENCE MATERIAL (CANMET, OTTAWA)	
SAMPLE MASS:	.995	GRAMS
COUNT PERIOD:	25200	SECONDS
COUNT DAY:	362	JULIAN 1985

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	883	BQ/G	RSD=3.4 %	

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	892	BQ/G	RSD=5.9 %	

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	827	BQ/G	RSD=3.6 %	**(857 Cert.)**

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	828	BQ/G	RSD=3.5 %	**(866 Cert.)**

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-3.12	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-5.42	BQ/G	RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	-.68	BQ/G	RSD=0 %
VIA TL-208(583.1KEV)	-2.3	BQ/G	RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	883	BQ/G	RSD=3.4 %
THORIUM-230	892	BQ/G	RSD=5.9 %
RADIUM-226	827	BQ/G	RSD=3.6 %
LEAD-210	828	BQ/G	RSD=3.5 %
RADIUM-228	-3.12	BQ/G	RSD=0 %
THORIUM-228	-.68	BQ/G	RSD=0 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	71800 **(70900 Cert.)**	PPM	RSD=3.4 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: UTS-4 STANDARD REFERENCE MATERIAL (CANMET, OTTAWA)
SAMPLE MASS: .974 GRAMS
COUNT PERIOD: 72000 SECONDS
COUNT DAY: 16 JULIAN 1986

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV) 13.3 BQ/G RSD=6 %

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV) 24.1 BQ/G RSD=15.7 % **(22.9 Cert.)**

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV) 37 BQ/G RSD=4.5 % **(38.6 Cert.)**

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV) 38.4 BQ/G RSD=4.4 % **(32.4 Cert.)**

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV) -.349 BQ/G RSD=0 %
VIA AC-228(969.1KEV) -.605 BQ/G RSD=0 %

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV) .129 BQ/G RSD=26.9 %
VIA TL-208(583.1KEV) -.265 BQ/G RSD=0 %

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	13.3	BQ/G	RSD=6 %
THORIUM-230	24.1	BQ/G	RSD=15.7 %
RADIUM-226	37	BQ/G	RSD=4.5 %
LEAD-210	38.4	BQ/G	RSD=4.4 %
RADIUM-228	-.349	BQ/G	RSD=0 %
THORIUM-228	.129	BQ/G	RSD=26.9 %

URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS:
FROM U-238 1080 PPM RSD=6 %
(1010 Cert.)

BECQUEREL LABORATORIES INC.
AECE PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RADIONUCLIDES OF INTEREST IN SOLID SAMPLES AS DETERMINED BY DIRECT GAMMA-RAY SPECTROMETRY.

SAMPLES OF APPROX. 1G WHICH ARE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS ARE COUNTED ON THE SURFACE OF A GERMANIUM DETECTOR.

MATERIAL: RA-226 POINT SOURCE, 195BQ (MANUFACTURER) ON AU/PT DISC
SAMPLE MASS: 1 GRAMS
COUNT PERIOD: 54... SECONDS
COUNT DAY: 362 JULIAN 1985

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

URANIUM-238 ESTIMATE

VIA TH-234(63.3KEV)	-15.7	BQ/G	RSD=0 %	

THORIUM-230 ESTIMATE

VIA TH-230(67.7KEV)	772	BQ/G	RSD=8.2 %	(Spurious Th-230 value caused by Au/Pt X-rays)

RADIUM-226 ESTIMATE

VIA RA-226(186.2KEV)	227	BQ/G	RSD=4.9 %	(195Bq Manuf. Cert. NBS traceable)

LEAD-210 ESTIMATE

VIA PB-210(46.5KEV)	-9.84	BQ/G	RSD=0 %	

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-3.15	BQ/G	RSD=0 %	
VIA AC-228(969.1KEV)	-5.86	BQ/G	RSD=0 %	

THORIUM-228 ESTIMATES

VIA PB-212(238.6KEV)	-.737	BQ/G	RSD=0 %	
VIA TL-208(583.1KEV)	-2.35	BQ/G	RSD=0 %	

SUMMARY OF PREFERRED VALUES CALCULATED FROM ABOVE ESTIMATES

URANIUM-238	-15.7	BQ/G	RSD=0 %
THORIUM-230	772	BQ/G	RSD=8.2 %
RADIUM-226	227	BQ/G	RSD=4.9 %
LEAD-210	-9.84	BQ/G	RSD=0 %
RADIUM-228	-3.15	BQ/G	RSD=0 %
THORIUM-228	-.737	BQ/G	RSD=0 %
URANIUM CONCENTRATION ASSUMING NATURAL ISOTOPE RATIOS: FROM U-238	-1277	PPM	RSD=0 %

APPENDIX D

ANALYSIS RESULTS: NEUTRON ACTIVATION ANALYSIS OF LUNG FLUID FRACTIONS FOR U-238

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: ELLIOT LAKE ORE 1.97G <38UM

LUNG FLUID FRACTION	S / F	U-238
U 7 :PRE-EXTRACTION WASH	38.9 / 341	680 UG (RSD=3 %)
U 8 :0-24 HOURS	96.9 / 979	250 UG (RSD=4 %)
U 9 :24-48 HOURS	103.6 / 1016	44 UG (RSD=6 %)
U 10 :48-96 HOURS	99.1 / 1009	35 UG (RSD=7 %)
U 11 :96-192 HOURS	99.2 / 1010	45 UG (RSD=6 %)
U 12 :192-384 HOURS	98.9 / 1024	41 UG (RSD=7 %)
U 13 :POST-EXTRACTION WASH	51.2 / 516	5.76 UG (RSD=19 %)

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: ELLIOT LAKE ORE 1.96G 53-75UM

LUNG FLUID FRACTION	S / F	U-238
U 28 :PRE-EXTRACTION WASH	32.8 / 420	139 UG (RSD=4 %)
U 29 :0-24 HOURS	47.3 / 924	78 UG (RSD=4 %)
U 30 :24-48 HOURS	65.7 / 959	7.55 UG (RSD=10 %)
U 31 :48-96 HOURS	94.2 / 846	39 UG (RSD=4 %)
U 32 :96-192 HOURS	80.3 / 807	7.15 UG (RSD=7 %)
U 33 :192-384 HOURS	97.8 / 1006	47 UG (RSD=4 %)
U 34 :POST-EXTRACTION WASH	55.5 / 602	14.61 UG (RSD=6 %)

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: MID-WEST ORE 1.87G <38UM

LUNG FLUID FRACTION	S / F	U-238
U 21 :PRE-EXTRACTION WASH	35.5 / 395	500 UG (RSD=3 %)
U 22 :0-24 HOURS	33.4 / 952	11200 UG (RSD=3 %)
U 23 :24-48 HOURS	42.2 / 908	7400 UG (RSD=3 %)
U 24 :48-96 HOURS	53.8 / 1011	8300 UG (RSD=3 %)
U 25 :96-192 HOURS	83.8 / 1009	5300 UG (RSD=3 %)
U 26 :192-384 HOURS	85.9 / 1050	4700 UG (RSD=3 %)
U 27 :POST-EXTRACTION WASH	50.3 / 507	690 UG (RSD=4 %)

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME : TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: MID-WEST ORE 1.986 53-75UM

LUNG FLUID FRACTION	S / F	U-238
U 14 :PRE-EXTRACTION WASH	38.1 / 349	172 UG (RSD=4 %)
U 15 :0-24 HOURS	91.7 / 891	3000 UG (RSD=3 %)
U 16 :24-48 HOURS	89.5 / 850	1120 UG (RSD=3 %)
U 17 :48-96 HOURS	93.5 / 920	740 UG (RSD=3 %)
U 18 :96-192 HOURS	94.5 / 989	1090 UG (RSD=3 %)
U 19 :192-384 HOURS	87.1 / 864	1190 UG (RSD=3 %)
U 20 :POST-EXTRACTION WASH	43.9 / 425	92 UG (RSD=5 %)

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: URANIUM DIOXIDE, FLUID BED, ELDORADO (0.258 GRAMS)

LUNG FLUID FRACTION	S / F	U-238
U 35 :0-24 HOURS	82.7 / 784	810 UG (RSD=3 %)
U 36 :24-48 HOURS	86.4 / 938	28 UG (RSD=5 %)
U 37 :48-96 HOURS	79.6 / 1047	33 UG (RSD=5 %)
U 38 :96-192 HOURS	91.6 / 1024	58 UG (RSD=4 %)
U 39 :192-384 HOURS	96.8 / 1014	134 UG (RSD=3 %)

BECQUEREL LABORATORIES INC.
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REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: URANIUM TRIOXIDE, ELDORADO **(0.292 GRAMS)**

LUNG FLUID FRACTION	S / F	U-238
U 40 :0-24 HOURS	13.3 / 512	52400 UG (RSD=3 %)
U 41 :24-48 HOURS	16.7 / 700	50200 UG (RSD=3 %)
U 42 :48-96 HOURS	21.7 / 698	41800 UG (RSD=3 %)
U 43 :96-192 HOURS	6.13 / 677	27700 UG (RSD=3 %)
U 44 :192-384 HOURS	9.52 / 947	31200 UG (RSD=3 %)

BECQUEREL LABORATORIES INC.
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REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: CASC FILT ST2 88UG U, YELL CAKE PACKING, MILL A DEN ELL LAKE

LUNG FLUID FRACTION	S / F	U-238
U 45 :0-24 HOURS	132 / 596	86 UG (RSD=3 %)
U 46 :24-48 HOURS	133 / 352	4.17 UG (RSD=6 %)
U 47 :48-96 HOURS	137 / 393	1.31 UG (RSD=11 %)
U 48 :96-192 HOURS	105 / 483	2.49 UG (RSD=8 %)
U 49 :192-384 HOURS	103 / 442	2.55 UG (RSD=8 %)

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NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: OPEN FACE FILTER 288UG U, WESTINGHOUSE PH LOC 7.27 85-6-12

LUNG FLUID FRACTION	S / F	U-238
U 50 :0-24 HOURS	101 / 597	6.24 UG (RSD=9 %)
U 51 :24-48 HOURS	103 / 308	.43 UG (RSD=21 %)
U 52 :48-96 HOURS	106 / 320	.64 UG (RSD=15 %)
U 53 :96-192 HOURS	104 / 352	.92 UG (RSD=13 %)
U 54 :192-384 HOURS	103 / 405	.81 UG (RSD=15 %)

BECQUEREL LABORATORIES INC.
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REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 100 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: SLF BLANK AND CANMET DL-1A U-ORE STD.

LUNG FLUID FRACTION	S / F	U-238
U 0 :SLF BLANK	90 / 1000	-1.85 UG (RSD=0 %)
U 1 :DL-1A STD. 116 PPM U	.297 / 1	116 UG (RSD=4 %)

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REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: ELLIOT LAKE ORE 25G 38-53UM PARTICLES

LUNG FLUID FRACTION	S / F	U-238
U 2 :"SATURATION" SOLUTION	12.4 / 827	8100 UG (RSD=3 %)

BECQUEREL LABORATORIES INC.
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REPORT ON U-238 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF U-238 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: MID-WEST ORE 25G <1.7MM PARTICLES

LUNG FLUID FRACTION	S / F	U-238
U 1 :"SATURATION" SOLUTION	11.3 / 835	64400 UG (RSD=3 %)

APPENDIX E

ANALYSIS RESULTS: ALPHA-SPECTROMETRY FOR Th-230 IN LUNG FLUID FRACTIONS

1. Test Material: Elliot Lake Ore 1.97g, ≤38um particles

Pre-Extraction Wash	0.032 Bq Th-230
0-24h	0.031 Bq
0-48h	0.046 Bq
48-96h	0.027 Bq
96-192h	0.037 Bq
192-384h	0.041 Bq
Post-Extraction Wash	0.023 Bq

2. Test Material: Elliot Lake Ore 1.96g, 53-75um particles

Pre-Extraction Wash	0.018 Bq Th-230
0-24h	0.024 Bq
0-48h	0.024 Bq
48-96h	0.018 Bq
96-192h	0.023 Bq
192-384h	0.030 Bq
Post-Extraction Wash	0.003 Bq

3. Test Material: Mid-West Ore 1.87g, ≤38um particles

Pre-Extraction Wash	0.193 Bq Th-230
0-24h	0.286 Bq
0-48h	0.314 Bq
48-96h	0.329 Bq
96-192h	0.263 Bq
192-384h	0.526 Bq
Post-Extraction Wash	0.500 Bq

4. Test Material: Mid-West Ore 1.98g, 53-75um particles

Pre-Extraction Wash	0.094 Bq Th-230
0-24h	0.147 Bq
0-48h	0.222 Bq
48-96h	0.241 Bq
96-192h	0.206 Bq
192-384h	0.338 Bq
Post-Extraction Wash	0.158 Bq

APPENDIX F

ANALYSIS RESULTS: GAMMA-RAY SPECTROMETRY FOR Ra-226 AND Ra-228 IN LUNG FLUID FRACTIONS

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS $BaSO_4$
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 1.97G <38UM	
SAMPLE:	PRE-EXTRACTION WASH (RA 7)	
SOLN. MASS:	55.9	GRAMS, FROM TOTAL SLF FRACTION OF 341 GRAMS
COUNT PERIOD:	36000	SECONDS
COUNT DAY:	28	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	-1.91000E-03	BQ/G	RSD=0 %
VIA PB-214(295.2KEV)	-3.17000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	-2.38000E-03	BQ/G	RSD=0 %
VIA RA-226(186.3KEV)	-.0136	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-4.04000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-7.04000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	-.65	BQ	RSD=0 %
RADIUM-228	-1.38	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS $BASO_4$
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 1.97G <38UM	
SAMPLE:	0-24H SLF FRACTION (RA 8)	
SOLN. MASS:	136	GRAMS, FROM TOTAL SLF FRACTION OF 979 GRAMS
COUNT PERIOD:	36000	SECONDS
COUNT DAY:	29	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	1.04000E-03	BQ/G	RSD=32.8 %
VIA PB-214(295.2KEV)	-1.39000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	1.63000E-03	BQ/G	RSD=26.8 %
VIA RA-226(186.3KEV)	-5.12000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.87000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-3.40000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	1.36	BQ	RSD=20.8 %
RADIUM-228	-1.83	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 1.97G <38UM	
SAMPLE:	24-48H SLF FRACTION (RA 9)	
SOLN. MASS:	135	GRAMS, FROM TOTAL SLF FRACTION OF 1016 GRAMS
COUNT PERIOD:	71987	SECONDS
COUNT DAY:	54	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	7.09000E-04	BQ/G	RSD=32.3 %
VIA PB-214(295.2KEV)	9.93000E-04	BQ/G	RSD=38.4 %
VIA BI-214(609.0KEV)	-7.13000E-04	BQ/G	RSD=0 %
VIA RA-226(186.3KEV)	-3.91000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.29000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	2.49000E-03	BQ/G	RSD=37.8 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	.84	BQ	RSD=24.7 %
RADIUM-228	-1.31	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUIDS

REPORT ON RA-226 AND RA 226 IN SOLUTION SAMPLES.

DETERMINATIONS VIA CORRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 1.97G <38UM	
SAMPLE:	48-96H SLF FRACTION (RA 10)	
SOLN. MASS:	138	GRAMS, FROM TOTAL SLF FRACTION OF 1009 GRAMS
COUNT PERIOD:	57590	SECONDS
COUNT DAY:	55	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	9.53000E-04	BQ/G	RSD=26.8 %
VIA PB-214(295.2KEV)	-1.09000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	-7.71000E-04	BQ/G	RSD=0 %
VIA RA-226(186.3KEV)	-4.29000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.42000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	2.52000E-03	BQ/G	RSD=39.7 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	-.78	BQ	RSD=0 %
RADIUM-228	-1.43	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 1.97G <38UM	
SAMPLE:	96-192H SLF FRACTION (RA 11)	
SOLN. MASS:	135	GRAMS, FROM TOTAL SLF FRACTION OF 1010 GRAMS
COUNT PERIOD:	37030	SECONDS
COUNT DAY:	60	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	-8.01000E-04	BQ/G	RSD=0 %
VIA PB-214(295.2KEV)	-1.37000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	1.37000E-03	BQ/G	RSD=30.6 %
VIA RA-226(186.3KEV)	-5.64000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.90000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-3.47000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	-.81	BQ	RSD=0 %
RADIUM-228	-1.92	BQ	RSD=0 %

BECQUEREL LABORATORIES LTD.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASED
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE LOT# 38UM	
SAMPLE:	192-384H SLF FRACTION (RA 12)	
SOLN. MASS:	143	GRAMS, FROM TOTAL SLF FRACTION OF 1024 GRAMS
COUNT PERIOD:	21720	SECONDS
COUNT DAY:	64	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	-9.63000E-04	BQ/G	RSD=0 %
VIA PB-214(295.2KEV)	-1.72000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	-1.39000E-03	BQ/G	RSD=0 %
VIA RA-226(186.3KEV)	-7.00000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.10000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-4.83000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	-.99	BQ	RSD=0 %
RADIUM-228	-2.15	BQ	RSD=0 %

RECOVERY LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM F.P. TYPE DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 1.97G -38UM	
SAMPLE:	POST-EXTRACTION SLF WASH (RA 13)	
SOLN. MASS:	99	GRAMS, FROM TOTAL SLF FRACTION OF 516 GRAMS
COUNT PERIOD:	39592	SECONDS
COUNT DAY:	66	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	1.16000E-03	BQ/G	RSD=36.6 %
VIA PB-214(295.2KEV)	-1.89000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	1.55000E-03	BQ/G	RSD=33.7 %
VIA RA-226(186.3KEV)	-6.93000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.44000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-4.14000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	.71	BQ	RSD=24.8 %
RADIUM-228	-1.26	BQ	RSD=0 %

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

MATERIAL: [illegible] GRAB SS-75UM

SAMPLE: ALL SLF FRACTIONS COMBINED

SOLN. MASS: 772 GRAMS, FROM TOTAL SLF FRACTION OF 5566 GRAMS

COUNT PERIOD: 7200 SECONDS

COUNT DATE: 114 JULIAN 1988

CHEM. YIELD: 90 PERCENT

BUILD-UP: 100 PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	2.58000E-04	BQ/G	RSD=34.7 %
VIA PB-214(295.2KEV)	-5.01000E-04	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	-4.28000E-04	BQ/G	RSD=0 %
VIA RA-226(186.3KEV)	-2.15000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-7.09000E-04	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-1.16000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	1.44	BQ	RSD=34.7 %
RADIUM-228	-3.95	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	PRE-EXTRACTION WASH (RA 21)	
SOLN. MASS:	41.5	GRAMS, FROM TOTAL SLF FRACTION OF 395 GRAMS
COUNT PERIOD:	36000	SECONDS
COUNT DAY:	106	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	.0246	BQ/G	RSD=8.6 %
VIA PB-214(295.2KEV)	.0218	BQ/G	RSD=13 %
VIA BI-214(609.0KEV)	.0229	BQ/G	RSD=10.8 %
VIA RA-226(186.3KEV)	-.0197	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-7.35000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-.0133	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	9.28	BQ	RSD=6 %
RADIUM-228	-2.9	BQ	RSD=0 %

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DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	0-24H SLF FRACTION (RA 22)	
SOLN. MASS:	103	GRAMS, FROM TOTAL SLF FRACTION OF 952 GRAMS
COUNT PERIOD:	43200	SECONDS
COUNT DAY:	108	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	.0159	BQ/G	RSD=6.6 %
VIA PB-214(295.2KEV)	.0151	BQ/G	RSD=8.5 %
VIA BI-214(609.0KEV)	.0146	BQ/G	RSD=8.2 %
VIA RA-226(186.3KEV)	-8.82000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.63000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-4.48000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	14.6	BQ	RSD=4.4 %
RADIUM-228	-2.5	BQ	RSD=0 %

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AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	24-48H SLF FRACTION (RA 23)	
SOLN. MASS:	90	GRAMS, FROM TOTAL SLF FRACTION OF 908 GRAMS
COUNT PERIOD:	29400	SECONDS
COUNT DAY:	110	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	.0117	BQ/G	RSD=9 %
VIA PB-214(295.2KEV)	.0123	BQ/G	RSD=11.7 %
VIA BI-214(609.0KEV)	.0138	BQ/G	RSD=9.9 %
VIA RA-226(186.3KEV)	-.0102	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-3.25000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-5.16000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	11.4	BQ	RSD=5.8 %
RADIUM-228	-2.95	BQ	RSD=0 %

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REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	48-96H SLF FRACTION (RA 24)	
SOLN. MASS:	106	GRAMS, FROM TOTAL SLF FRACTION OF 1011 GRAMS
COUNT PERIOD:	28800	SECONDS
COUNT DAY:	110	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	8.40000E-03	BQ/G	RSD=9.9 %
VIA PB-214(295.2KEV)	8.30000E-03	BQ/G	RSD=13.6 %
VIA BI-214(609.0KEV)	8.32000E-03	BQ/G	RSD=12.2 %
VIA RA-226(186.3KEV)	-9.40000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.92000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-5.68000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	8.44	BQ	RSD=6.7 %
RADIUM-228	-2.95	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	96-192H SLF FRACTION (RA 25)	
SOLN. MASS:	103	GRAMS, FROM TOTAL SLF FRACTION OF 1009 GRAMS
COUNT PERIOD:	28800	SECONDS
COUNT DAY:	110	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	8.64000E-03	BQ/G	RSD=9.9 %
VIA PB-214(295.2KEV)	8.54000E-03	BQ/G	RSD=13.6 %
VIA BI-214(609.0KEV)	8.56000E-03	BQ/G	RSD=12.2 %
VIA RA-226(186.3KEV)	-9.67000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-3.01000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-5.85000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	8.67	BQ	RSD=6.7 %
RADIUM-228	-3.04	BQ	RSD=0 %

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AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	192-384H SLF FRACTION (RA 26)	
SOLN. MASS:	109	GRAMS, FROM TOTAL SLF FRACTION OF 1050 GRAMS
COUNT PERIOD:	14400	SECONDS
COUNT DAY:	113	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	8.58000E-03	BQ/G	RSD=12.4 %
VIA PB-214(295.2KEV)	6.58000E-03	BQ/G	RSD=21.2 %
VIA BI-214(609.0KEV)	7.73000E-03	BQ/G	RSD=16.8 %
VIA RA-226(186.3KEV)	-.0126	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-3.08000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-6.49000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	8.37	BQ	RSD=9 %
RADIUM-228	-3.23	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.87G <38UM	
SAMPLE:	POST-EXTRACTION WASH (RA 27)	
SOLN. MASS:	46.7	GRAMS, FROM TOTAL SLF FRACTION OF 507 GRAMS
COUNT PERIOD:	28800	SECONDS
COUNT DAY:	114	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	.0134	BQ/G	RSD=11.7 %
VIA PB-214(295.2KEV)	8.33000E-03	BQ/G	RSD=24.8 %
VIA BI-214(609.0KEV)	.0119	BQ/G	RSD=15.2 %
VIA RA-226(186.3KEV)	-.0178	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-6.00000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-9.78000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	6.23	BQ	RSD=8.7 %
RADIUM-228	-3.04	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	PRE-EXTRACTION WASH (RA 14)	
SOLN. MASS:	61.9	GRAMS, FROM TOTAL SLF FRACTION OF 349 GRAMS
COUNT PERIOD:	35749	SECONDS
COUNT DAY:	66	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	.0104	BQ/G	RSD=10.8 %
VIA PB-214(295.2KEV)	9.29000E-03	BQ/G	RSD=16.7 %
VIA BI-214(609.0KEV)	.0117	BQ/G	RSD=11.8 %
VIA RA-226(186.3KEV)	-.012	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-4.13000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-6.72000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	3.73	BQ	RSD=7.2 %
RADIUM-228	-1.44	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
AECB PROJECT - SOLUBILITY OF MATERIALS IN SIMULATED LUNG FLUID

REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	0-24H SLF FRACTION (RA 15)	
SOLN. MASS:	139	GRAMS, FROM TOTAL SLF FRACTION OF 891 GRAMS
COUNT PERIOD:	25200	SECONDS
COUNT DAY:	30	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	8.36000E-03	BQ/G	RSD=9 %
VIA PB-214(295.2KEV)	8.04000E-03	BQ/G	RSD=12.3 %
VIA BI-214(609.0KEV)	7.95000E-03	BQ/G	RSD=11.2 %
VIA RA-226(186.3KEV)	-6.55000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.14000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-3.75000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	7.27	BQ	RSD=6.1 %
RADIUM-228	-1.91	BQ	RSD=0 %

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DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	24-48H SLF FRACTION (RA 16)	
SOLN. MASS:	135	GRAMS, FROM TOTAL SLF FRACTION OF 850 GRAMS
COUNT PERIOD:	86384	SECONDS
COUNT DAY:	67	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	.0114	BQ/G	RSD=5.7 %
VIA PB-214(295.2KEV)	.0104	BQ/G	RSD=7.4 %
VIA BI-214(609.0KEV)	.0114	BQ/G	RSD=6.5 %
VIA RA-226(186.3KEV)	.0109	BQ/G	RSD=15.8 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.27000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-2.28000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	9.47	BQ	RSD=3.6 %
RADIUM-228	-1.08	BQ	RSD=0 %

BECQUEREL LABORATORIES INC.
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REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4 ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	48-96H SLF FRACTION (RA 17)	
SOLN. MASS:	143	GRAMS, FROM TOTAL SLF FRACTION OF 920 GRAMS
COUNT PERIOD:	43200	SECONDS
COUNT DAY:	69	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	7.90000E-03	BQ/G	RSD=7.7 %
VIA PB-214(295.2KEV)	6.41000E-03	BQ/G	RSD=11.6 %
VIA BI-214(609.0KEV)	8.00000E-03	BQ/G	RSD=9.1 %
VIA RA-226(186.3KEV)	5.66000E-03	BQ/G	RSD=34.9 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.74000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-3. 000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	6.98	BQ	RSD=5.2 %
RADIUM-228	-1.6	BQ	RSD=0 %

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REPORT ON RA-226 AND RA-228 IN SULUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	96-192H SLF FRACTION (RA 18)	
SOLN. MASS:	135	GRAMS, FROM TOTAL SLF FRACTION OF 989 GRAMS
COUNT PERIOD:	71981	SECONDS
COUNT DAY:	73	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	7.88000E-03	BQ/G	RSD=6.9 %
VIA PB-214(295.2KEV)	7.14000E-03	BQ/G	RSD=9.4 %
VIA BI-214(609.0KEV)	7.76000E-03	BQ/G	RSD=8.2 %
VIA RA-226(186.3KEV)	9.17000E-03	BQ/G	RSD=19.4 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.48000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-2.66000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	7.66	BQ	RSD=4.5 %
RADIUM-228	-1.46	BQ	RSD=0 %

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REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	192-384H SLF FRACTION (RA 19)	
SOLN. MASS:	138	GRAMS, FROM TOTAL SLF FRACTION OF 864 GRAMS
COUNT PERIOD:	72000	SECONDS
COUNT DAY:	85	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	8.81000E-03	BQ/G	RSD=6.5 %
VIA PB-214(295.2KEV)	8.01000E-03	BQ/G	RSD=8.6 %
VIA BI-214(609.0KEV)	8.75000E-03	BQ/G	RSD=7.6 %
VIA RA-226(186.3KEV)	7.28000E-03	BQ/G	RSD=22.9 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-1.35000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-2.24000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	7.39	BQ	RSD=4.2 %
RADIUM-228	-1.17	BQ	RSD=0 %

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REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM IN BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4 ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 1.98G 53-75UM	
SAMPLE:	POST-EXTRACTION WASH (RA 20)	
SOLN. MASS:	83.2	GRAMS, FROM TOTAL SLF FRACTION OF 425 GRAMS
COUNT PERIOD:	36600	SECONDS
COUNT DAY:	89	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	6.22000E-03	BQ/G	RSD=12 %
VIA PB-214(295.2KEV)	7.27000E-03	BQ/G	RSD=14.9 %
VIA BI-214(609.0KEV)	6.35000E-03	BQ/G	RSD=13.9 %
VIA RA-226(186.3KEV)	-9.03000E-03	BQ/G	RSD=275006 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.93000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-4.92000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	2.78	BQ	RSD=7.8 %
RADIUM-228	-1.25	BQ	RSD=0 %

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REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	ELLIOT LAKE ORE 25G 38-53UM	
SAMPLE:	"SATURATION" SOLUTION	
SOLN. MASS:	75.2	GRAMS, FROM TOTAL SLF FRACTION OF 827 GRAMS
COUNT PERIOD:	43200	SECONDS
COUNT DAY:	24	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	1.93000E-03	BQ/G	RSD=28 %
VIA PB-214(295.2KEV)	-2.25000E-03	BQ/G	RSD=0 %
VIA BI-214(609.0KEV)	-1.67000E-03	BQ/G	RSD=0 %
VIA RA-226(186.3KEV)	-8.97000E-03	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-2.83000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-5.40000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	-1.38	BQ	RSD=0 %
RADIUM-228	-2.34	BQ	RSD=0 %

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REPORT ON RA-226 AND RA-228 IN SOLUTION SAMPLES.

DETERMINATIONS VIA COPRECIPITATION OF RADIUM ON
BARIUM SULPHATE FOLLOWED BY GAMMA-SPECTROMETRY.

SAMPLES ARE COUNTED ON SURFACE OF GE DETECTOR AS BASO4
ON 25MM FILTERS DOUBLY ENCAPSULATED IN 2 MIL LAY-FLAT
POLYETHYLENE BAGS.

MATERIAL:	MID-WEST ORE 25G <1.7MM (AS SUPPLIED)	
SAMPLE:	"SATURATION" SOLUTION	
SOLN. MASS:	76.5	GRAMS, FROM TOTAL SLF FRACTION OF 835 GRAMS
COUNT PERIOD:	43200	SECONDS
COUNT DAY:	23	JULIAN 1986
CHEM. YIELD:	90	PERCENT
BUILD-UP:	100	PERCENT

(NOTE THAT MINUS SIGNS INDICATE 'LESS THAN' VALUES)

RADIUM-226 ESTIMATES

VIA PB-214(351.9KEV)	8.92000E-03	BQ/G	RSD=10 %
VIA PB-214(295.2KEV)	7.79000E-03	BQ/G	RSD=15.7 %
VIA BI-214(609.0KEV)	8.57000E-03	BQ/G	RSD=12.8 %
VIA RA-226(186.3KEV)	-.0113	BQ/G	RSD=0 %

RADIUM-228 ESTIMATES

VIA AC-228(911.1KEV)	-3.52000E-03	BQ/G	RSD=0 %
VIA AC-228(969.1KEV)	-6.16000E-03	BQ/G	RSD=0 %

SUMMARY OF RADIUM CONCENTRATIONS FOR TOTAL SLF FRACTION

RADIUM-226	7.17	BQ	RSD=7 %
RADIUM-228	-2.94	BQ	RSD=0 %

APPENDIX G

ANALYSIS RESULTS: ALPHA-SPECTROMETRY FOR Pb-210 IN LUNG FLUID FRACTIONS

1. Test Material: Elliot Lake Ore 1.97g, ≤38um particles

Pre-Extraction Wash	0.005 Bq Pb-210
0-24h	0.071 Bq
0-48h	0.031 Bq
48-96h	0.025 Bq
96-192h	0.024 Bq
192-384h	0.037 Bq
Post-Extraction Wash	0.020 Bq

2. Test Material: Elliot Lake Ore 1.96g, 53-75um particles

Pre-Extraction Wash	0.008 Bq Pb-210
0-24h	0.008 Bq
0-48h	0.010 Bq
48-96h	0.012 Bq
96-192h	0.016 Bq
192-384h	0.018 Bq
Post-Extraction Wash	0.050 Bq

3. Test Material: Mid-West Ore 1.87g, ≤38um particles

Pre-Extraction Wash	0.061 Bq Pb-210
0-24h	0.201 Bq
0-48h	0.112 Bq
48-96h	0.157 Bq
96-192h	0.239 Bq
192-384h	0.228 Bq
Post-Extraction Work	0.950 Bq

4. Test Material: Mid-West Ore 1.98g, 53-75um particles

Pre-Extraction Wash	0.110 Bq Pb-210
0-24h	0.109 Bq
0-48h	0.121 Bq
48-96h	0.132 Bq
96-192h	0.203 Bq
192-384h	0.169 Bq
Post-Extraction Wash	0.102 Bq

APPENDIX H

ANALYSIS RESULTS: ALPHA-SPECTROMETRY FOR Po-210 IN LUNG FLUID FRACTIONS

1. Test Material: Elliot Lake Ore 1.97g, ≤38um particles

Pre-Extraction Wash	0.012 Bq Po-210
0-24h	0.103 Bq
0-48h	0.055 Bq
48-96h	0.055 Bq
96-192h	0.041 Bq
192-384h	0.051 Bq
Post-Extraction Wask	0.044 Bq

2. Test Material: Elliot Lake Ore 1.96g, 53-75um particles

Pre-Extraction Wash	0.016 Bq Po-210
0-24h	0.007 Bq
0-48h	0.014 Bq
48-96h	0.009 Bq
96-192h	0.010 Bq
192-384h	0.012 Bq
Post-Extraction Wash	0.075 Bq

3. Test Material: Mid-West Ore 1.87g, ≤38um particles

Pre-Extraction Wash	0.091 Bq Po-210
0-24h	0.246 Bq
0-48h	0.153 Bq
48-96h	0.274 Bq
96-192h	0.349 Bq
192-384h	0.265 Bq
Post-Extraction Wash	1.960 Bq

4. Test Material: Mid-West Ore 1.98g, 53-75um particles

Pre-Extraction Wash	0.212 Bq Po-210
0-24h	0.171 Bq
0-48h	0.218 Bq
48-96h	0.309 Bq
96-192h	0.456 Bq
192-384h	0.405 Bq
Post-Extraction Wash	0.326 Bq

APPENDIX I

ANALYSIS RESULTS: NEUTRON ACTIVATION ANALYSIS OF LUNG FLUID FRACTIONS FOR Th-232

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REPORT ON TH-232 IN SIMULATED LUNG FLUID SAMPLES. MEASUREMENT VIA NEUTRON ACTIVATION ANALYSIS AFTER PRECONCENTRATION OF THE ANALYTES BY COPRECIPITATION ON ALUMINUM OXINATE.

NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: ELLIOT LAKE ORE 1.97G <38UM

LUNG FLUID FRACTION	S / F	TH-232
TH 7 :PRE-EXTRACTION WASH	38.9 / 341	6 UG (RSD=11 %)
TH 8 :0-24 HOURS	96.9 / 979	-.82 UG (RSD=0 %)
TH 9 :24-48 HOURS	103.6 / 1016	-.41 UG (RSD=0 %)
TH 10 :48-96 HOURS	99.1 / 1009	-.51 UG (RSD=0 %)
TH 11 :96-192 HOURS	99.2 / 1010	-.49 UG (RSD=0 %)
TH 12 :192-384 HOURS	98.9 / 1024	1.04 UG (RSD=33 %)
TH 13 :POST-EXTRACTION WASH	51.2 / 516	1.9 UG (RSD=21 %)

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NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: ELLIOT LAKE ORE 1.96G 53-75UM

LUNG FLUID FRACTION	S / F	TH-232
TH 28 :PRE-EXTRACTION WASH	32.8 / 420	1.89 UG (RSD=22 %)
TH 29 :0-24 HOURS	47.3 / 924	-.82 UG (RSD=0 %)
TH 30 :24-48 HOURS	65.7 / 959	-.63 UG (RSD=0 %)
TH 31 :48-96 HOURS	94.2 / 848	-.4 UG (RSD=0 %)
TH 32 :96-192 HOURS	80.3 / 807	-.3 UG (RSD=0 %)
TH 33 :192-384 HOURS	97.8 / 1006	-.32 UG (RSD=0 %)
TH 34 :POST-EXTRACTION WASH	55.5 / 602	.57 UG (RSD=30 %)

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NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: MID-WEST ORE 1.87G <38UM

LUNG FLUID FRACTION	S / F	TH-232
TH 21 :PRE-EXTRACTION WASH	31.1 / 395	-2.8 UG (RSD=0 %)
TH 22 :0-24 HOURS	76.4 / 952	-3.9 UG (RSD=0 %)
TH 23 :24-48 HOURS	87.9 / 908	-2.8 UG (RSD=0 %)
TH 24 :48-96 HOURS	70.3 / 1011	-2.7 UG (RSD=0 %)
TH 25 :96-192 HOURS	83.8 / 1009	-2.5 UG (RSD=0 %)
TH 26 :192-384 HOURS	85.9 / 1050	-2.7 UG (RSD=0 %)
TH 27 :POST-EXTRACTION WASH	50.3 / 507	-1.9 UG (RSD=0 %)

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NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: MID-WEST ORE 1.98G 53-75UM

LUNG FLUID FRACTION	S / F	TH-232
TH 14 :PRE-EXTRACTION WASH	38.1 / 349	1.11 UG (RSD=43 %)
TH 15 :0-24 HOURS	91.7 / 891	-1.76 UG (RSD=0 %)
TH 16 :24-48 HOURS	89.5 / 850	-1.25 UG (RSD=0 %)
TH 17 :48-96 HOURS	93.5 / 920	-1.12 UG (RSD=0 %)
TH 18 :96-192 HOURS	94.5 / 989	-1.33 UG (RSD=0 %)
TH 19 :192-384 HOURS	87.1 / 864	-1.25 UG (RSD=0 %)
TH 20 :POST-EXTRACTION WASH	43.9 / 425	-.77 UG (RSD=0 %)

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NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: ELLIOT LAKE ORE 25G 38-53UM PARTICLES

LUNG FLUID FRACTION	S / F	TH-232
TH 2 :"SATURATION" SOLUTION	12.4 / 827	-7.1 UG (RSD=0 %)

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NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 95 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: MID-WEST ORE 25G <1.7MM PARTICLES

LUNG FLUID FRACTION	S / F	TH-232
TH 1 :"SATURATION" SOLUTION	11.3 / 835	18.16 UG (RSD=44 %)

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NOTES:
RESULTS ARE MASS OF TH-232 IN TOTAL SLF FRACTION.
MINUS SIGNS INDICATE 'LESS THAN' VALUES.
S/F = ANALYZED SAMPLE VOLUME / TOTAL SLF FRACTION VOLUME.
CHEMICAL YIELD FACTOR APPLIED 100 % .
RSD = RELATIVE STANDARD DEVIATION (3% + 1 SIGMA STATISTICS).

TEST MATERIAL: SLF BLANK AND CANMET DL-1A U-ORE STD.

LUNG FLUID FRACTION	S / F	TH-232
TH 0 :SLF BLANK	90 / 1000	-.69 UG (RSD=0 %)
TH 1 :DL-1A STD. 76 PPM TH	.297 / 1	78 UG (RSD=4 %)